PRICE $2.00

HEATH COMPANY BENTON HARBOR, MICHIGAN

# HEATHKIT®
# ASSEMBLY MANUAL

HEATHKIT® by DAYSTROM

## IGNITION ANALYZER

MODEL IO-20

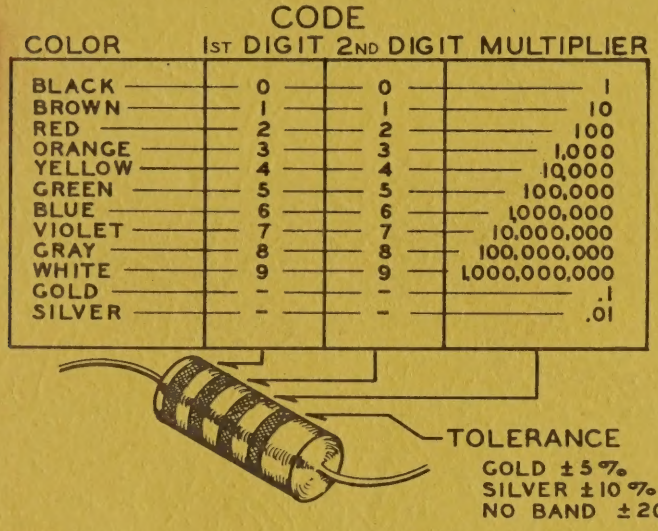
# RESISTOR AND CAPACITOR COLOR CODES

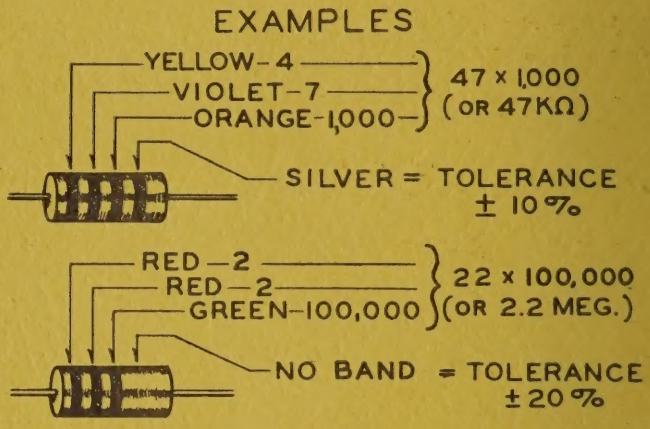
## RESISTORS

The colored bands around the body of a color coded resistor represent its value in ohms. These colored bands are grouped toward one end of the resistor body. Starting with this end of the resistor, the first band represents the first digit of the resistance value; the second band represents the second digit; the third band represents the number by which the first two digits are multiplied. A fourth band of gold or silver represents a tolerance of ±5% or ±10% respectively. The absence of a fourth band indicates a tolerance of ±20%.

The physical size of a composition resistor is related to its wattage rating. Size increases progressively as the wattage rating is increased. The diameters of 1/2 watt, 1 watt and 2 watt resistors are approximately 1/8", 1/4" and 5/16", respectively.

The color code chart and examples which follow provide the information required to identify color coded resistors.

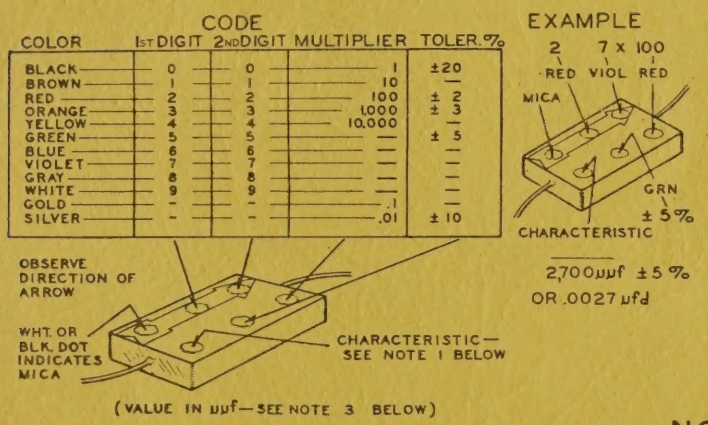



## CAPACITORS

Generally, only mica and tubular ceramic capacitors, used in modern equipment, are color coded. The color codes differ somewhat among capacitor manufacturers, however the codes shown below apply to practically all of the mica and tubular ceramic capacitors that are in common use. These codes comply with EIA (Electronics Industries Association) Standards.

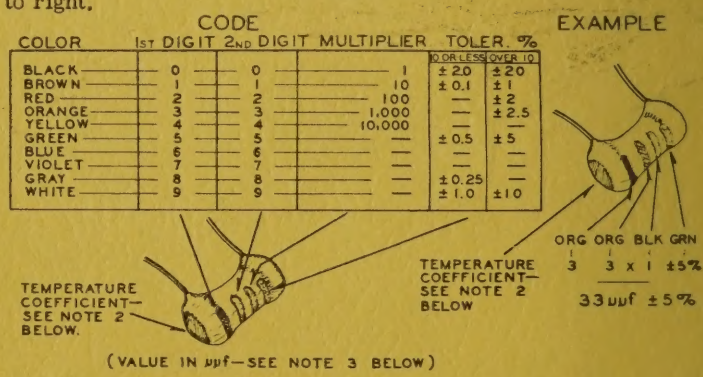
### MICA


CODE
COLOR
1ST DIGIT
2ND DIGIT
MULTIPLIER
TOLER.%
BLACK 0 0 1 ±20
BROWN 1 1 10 —
RED 2 2 100 ± 2
ORANGE 3 3 1,000 ± 3
YELLOW 4 4 10,000 —
GREEN 5 5 — ± 5
BLUE 6 6 — —
VIOLET 7 7 — —
GRAY 8 8 — —
WHITE 9 9 — —
GOLD - - .1 —
SILVER - - .01 ±10
OBSERVE DIRECTION OF ARROW
WHT. OR BLK. DOT INDICATES MICA
CHARACTERISTIC— SEE NOTE 1 BELOW
(VALUE IN μμf—SEE NOTE 3 BELOW)




### TUBULAR CERAMIC

Place the group of rings or dots to the left and read from left to right.


CODE
COLOR
1ST DIGIT
2ND DIGIT
MULTIPLIER
TOLER. %
10 OR LESS
OVER 10
BLACK 0 0 1 ±2.0 ±20
BROWN 1 1 10 ±0.1 ±1
RED 2 2 100 — ±2
ORANGE 3 3 1,000 — ±2.5
YELLOW 4 4 10,000 — —
GREEN 5 5 — ±0.5 ±5
BLUE 6 6 — — —
VIOLET 7 7 — — —
GRAY 8 8 — ±0.25 —
WHITE 9 9 — ±1.0 ±10
TEMPERATURE COEFFICIENT— SEE NOTE 2 BELOW.
TEMPERATURE COEFFICIENT— SEE NOTE 2 BELOW
(VALUE IN μμf—SEE NOTE 3 BELOW)




## NOTES:

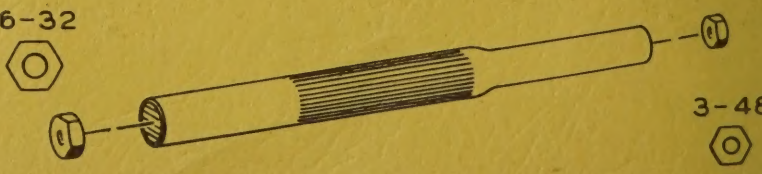
1. The characteristic of a mica capacitor is the temperature coefficient, drift capacitance and insulation resistance. This information is not usually needed to identify a capacitor but, if desired, it can be obtained by referring to EIA Standard, RS-153 (a Standard of Electronic Industries Association.)

2. The temperature coefficient of a capacitor is the predictable change in capacitance with temperature change and is expressed in parts per million per degree centigrade. Refer to EIA Standard, RS-198 (a Standard of Electronic Industries Association.)

3. The farad is the basic unit of capacitance, however capacitor values are generally expressed in terms of μfd (microfarad, .000001 farad) and μμf (micro-micro-farad, .000001 μfd); therefore, 1,000 μμf = .001 μfd, 1,000,000 μμf = 1μfd.

## USING A PLASTIC NUT STARTER

A plastic nut starter offers a convenient method of starting the most used sizes: 3/16" and 1/4" (3-48 and 6-32). When the correct end is pushed down over a nut, the pliable tool conforms to the shape of the nut and the nut is gently held while it is being picked up and started on the screw. The tool should only be used to start the nut.



Purchased Oct 19, 62

# Assembly and Operation of the

HEATHKIT by DAYSTROM

# IGNITION ANALYZER

MODEL IO-20

HEATH COMPANY,
BENTON HARBOR,
MICHIGAN

a subsidiary of DAYSTROM, INCORPORATED

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# SPECIFICATIONS

| | |
|---|---|
| RPM Range: | 400-5000. |
| Display Shows | |
| Primary: | Voltage across breaker points. |
| Secondary: | Voltage in secondary circuit. |
| Parade: | Primary or secondary signals for each cylinder in sequence across screen. |
| Superimposed: | Primary or secondary signals for all cylinders in sequence across screen. |
| Screen Size: | 4-1/2" diameter. |
| Standard Pattern Height | |
| Primary Circuit | |
| 6 Volt System: | Approximately 3/4". |
| 12 Volt System: | Approximately 1". |
| Secondary Circuit: | Approximately 1". |
| Vertical Expand Ratio: | Approximately 2 to 1. |
| Horizontal Expand Ratio: | Approximately 10 to 1. |
| Cable Length | |
| Cable To Pickup Clamp: | 12 feet. |
| Pickup Clamp To Ground, Primary And Secondary Clips: | 2 feet. |
| Trigger Method: | Clamp-on current transformer in a rugged plastic clamp. |
| Front Panel Controls: | VERTical position.<br>RIGHT EDGE and LEFT EDGE.<br>PARADE-SUPERIMPOSED.<br>VERTICAL EXPAND.<br>Function Selector: OFF, SECONDARY EXPAND, SECONDARY NORMAL, PRIMARY NORMAL, PRIMARY EXPAND, ACCESSORY. |
| Internal Controls: | FOCUS<br>ASTIGMATISM (Spot Shape)<br>TRIGGER ADJUST |
| Tube Complement: | 5UP1, 1V2, 6EA8, 12AU7 (2), 12AX7 (2). |

| | |
|---|---|
| Rectifiers: | Silicon (3). |
| Power Requirements: | 105-125 volts AC 50-60 cycles, 30 watts. |
| Overall Dimensions: | 8" high x 9-1/2" wide x 16" long. |
| Net Weight: | 12 lbs. |
| Shipping Weight: | 15 lbs. |

# INTRODUCTION

The IO-20 Ignition Analyzer is a valuable tool for the garage mechanic, service station operator, and the auto hobbyist.

After you become familiar with this instrument you can rapidly analyze the ignition system of an internal combustion engine. This instrument changes the electrical pulses of the ignition system into a visual display from which the operator can determine if each component is functioning properly.

For easy operation the IO-20 has a minimum of front panel controls. A switch is provided on the front panel to enable you to alternately view primary or secondary ignition patterns without changing the hookup to the engine. The large display screen is marked in degrees of dwell, making possible rapid checking of dwell angle.

The cathode ray tube used in this instrument is protected from stray magnetic fields by the special alloy shield.

The Ignition Analyzer can be regarded as a tool. As with many other tools, experience and skill in handling and interpretation increases the ability to use the tool to its utmost advantage.

# CIRCUIT DESCRIPTION

The IO-20 Ignition Analyzer has six basic sections which are the Trigger Circuit, Sweep Generator, Horizontal Deflection Amplifier, Vertical Amplifier, Power Supply, and the CR tube circuit. The overall relationship of each of these sections is shown by the Functional Block Diagram on Page 4.

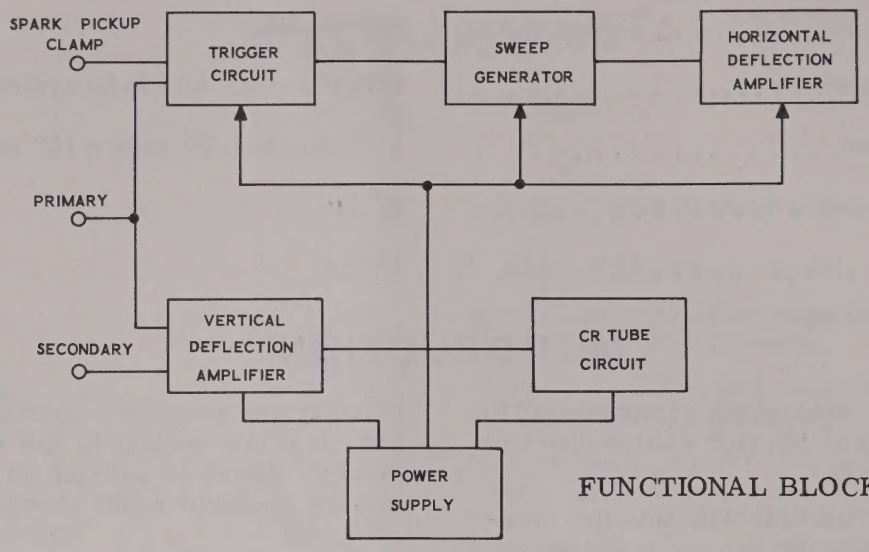
Each individual section will be discussed in the above order. We suggest that while reading the Circuit Description, you follow the circuit on the Schematic Diagram and the Functional Block Diagram.

## Trigger Circuit

In order to obtain horizontal sweep for the CR tube, in the PARADE position, it is necessary to trigger the Horizontal Sweep Circuit each time a particular spark plug fires. This trigger voltage is obtained from the engine being analyzed. A current transformer (Spark Pickup Clamp) is clipped around the particular spark plug wire. Each time the spark plug connected to this wire fires, the current flowing through the spark plug wire develops a small voltage spike in the current transformer. This is fed to the cathode of V1A through the filter network C1, L1, and C2.

V1A operates as a grounded-grid amplifier, increasing the size of the trigger pulse. The TRIGGER ADJUST control R2 determines the gain of V1A. The amplified pulse from V1A is fed directly to V1B, which operates as a cathode follower to isolate the trigger circuit from the pulse generator circuit. The triggering pulse for the pulse generator multivibrator is coupled from V1B to the grid of V2A by coupling capacitor C8.

In order for the analyzer to show a SUPERIMPOSED display it is necessary to trigger the Pulse Generator for every spark plug firing. This is accomplished by taking each voltage pulse from the primary of the ignition coil and applying it through SW-2 to the screen grid of V1A. These pulses are amplified and coupled to the Pulse Generator through cathode follower V1B.




FUNCTIONAL BLOCK DIAGRAM

## Sweep Generator

The pulse generator, tube V2, operates as a conventional one-shot multivibrator. The trigger pulse from the cathode of V1B varies somewhat in amplitude and width. For this reason it is not desirable as a source for a linear sweep voltage. Therefore, the pulse is applied to the grid of the one-shot multivibrator which produces a pulse of the same repetition rate but of a constant amplitude and width.

This uniform pulse is then coupled to the Sweep Charging Diode D4, through cathode follower V3A. The LEFT EDGE control R12 determines the amount of charging voltage supplied to D4. By varying this voltage, the position of the trace beginning on the CR tube can be changed.

The Sweep Charging Diode D4 conducts as the voltage pulse increases in the positive direction. This charges the sweep forming capacitors C12 and C13.

The sweep forming capacitors discharge through R14 and R36, the RIGHT EDGE control. The voltage across R14 and R36 is maintained at a constant level by the neon lamp and the cathode follower V3B. This condition causes the voltage discharge of C12 and C13 to occur at a linear rate per unit of time, thus producing a linear sawtooth voltage. This sawtooth voltage is then coupled to one grid of the Horizontal Amplifier V4.

## Horizontal Deflection Amplifier

The Horizontal Amplifier circuit operates as a push-pull type of amplifier. Triode section V4A operates simultaneously as an amplifier and a cathode follower. The cathode of V4A and the cathode of V4B are connected together with R17 as a common cathode resistor. Therefore, any signal applied to the grid of V4A is applied to V4B by cathode follower action. V4B is operating as a grounded-grid amplifier such that a signal applied to its cathode will be amplified without any phase inversion. V4A operates as a conventional amplifier and therefore, signal voltages across the plate load resistors R19 and R20 will be opposite in phase, resulting in push-pull operation of the horizontal deflection plates.

## Vertical Deflection Amplifier

When the primary and secondary pickup clips are connected to their appropriate points in the ignition system being analyzed, the signal voltages developed at these points are coupled by the test cable to switch SW-1D. The signal is then coupled through the attenuator network to the grid of V5A. The attenuator network and bypass capacitors C14 and C15 reduce the signal voltages to the desired amplitude and remove some of the voltage spikes that develop when the points open.

VERTICAL EXPAND switch SW-3 is connected in such a manner that for normal amplitude displays the voltage is limited by R27. In the EXPAND position the switch short circuits R27, applying approximately twice the signal voltage to the grid of V5A.

The Vertical Amplifier tube V5 operates as a push-pull amplifier in the same manner as the Horizontal Amplifier V4. The output of V5 is

applied to the vertical deflection plates of V6, the CR tube.

Vertical centering of the trace is accomplished by varying the bias voltage on the grid of V5B. This is done with the VERTICAL POSITION control R32.

Power Supply

Two power sources are used in the IO-20. The High Voltage CR Tube Supply and the Low Voltage B+ Supply.

The high -DC voltage is obtained from the 1V2 rectifier tube V7 and the filter circuit R45, C22A and C22B. This -DC voltage is then applied to the appropriate elements of the CR tube through a voltage divider. The neon lamp which is used in the sweep circuit is also used as a pilot lamp indicating the presence of high voltage.

The Low Voltage B+ Supply utilizes a voltage tripler circuit consisting of three silicon diodes (D1, D2, D3) and three capacitors (C19, C20 and C21A).

A 1/2 ampere fuse in the primary circuit of the power transformer protects the IO-20 circuitry.

CR Tube Circuit

The CR Tube Circuit includes a 5UP1 CR tube, a FOCUS control, an ASTIGMATISM control, and several fixed resistors.

The intensity is preadjusted to an optimum level by the use of a self-biasing resistor (R41).

The FOCUS control enables you to adjust the voltage on the focusing electrode of the CR tube for the sharpest trace.

The ASTIGMATISM control permits adjustment of the voltage on the second anode within the CR tube. This control is used to obtain the best overall trace clarity and definition.

Accessory Socket

The octal socket on the rear of the chassis makes several important circuit points easily accessible without removing the chassis from the cabinet. These circuit points are shown on the Schematic Diagram.

## CONSTRUCTION NOTES

This manual is supplied to assist you in every way to complete your kit with the least possible chance for error. The arrangement shown is the result of extensive experimentation and trial. If followed carefully, the result will be a stable instrument, operating at a high degree of dependability. We suggest that you retain the manual in your files for future reference, both in the use of the instrument and for its maintenance.

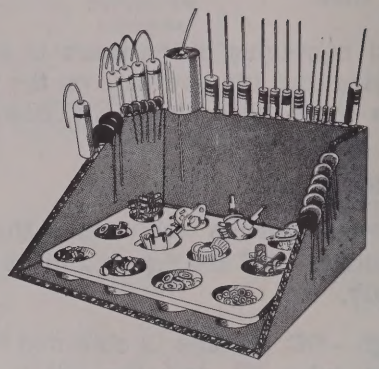
UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with the parts. Refer to the charts and other information on the inside covers of the manual to help you identify the components. If some shortage or parts damage is found in checking the Parts List, please read the REPLACEMENT section and supply the information called for therein. Include all inspection slips in your letter to us.

Resistors generally have a tolerance rating of 10% unless otherwise stated in the Parts List. Tolerances on capacitors are generally even greater. Limits of +100% and -20% are common for electrolytic capacitors.

We suggest that you do the following before work is started:

1. Lay out all parts so that they are readily available.
2. Provide yourself with good quality tools. Basic tool requirements consist of a screwdriver with a 1/4" blade; a small screwdriver with a 1/8" blade; long-nose pliers; wire cutters, preferably separate diagonal cutters; a pen knife or a tool for stripping insulation from wires; a soldering iron (or gun) and rosin core solder. A set of nut drivers and a nut starter, while not necessary, will aid extensively in construction of the kit.

Most kit builders find it helpful to separate the various parts into convenient categories. Muffin tins or molded egg cartons make convenient trays for small parts. Resistors and capacitors may be placed with their lead ends inserted in the edge of a piece of corrugated cardboard until they are needed. Values can be written on the cardboard next to each component. The illustration shows one method that may be used.



# PARTS LIST

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| **Resistors** | | |
| 1-7 | 1 | 680 Ω 1/2 watt (blue-gray-brown) |
| 1-9 | 1 | 1000 Ω 1/2 watt (brown-black-red) |
| 1-11 | 1 | 1500 Ω 1/2 watt (brown-green-red) |
| 1-14 | 1 | 3300 Ω 1/2 watt (orange-orange-red) |
| 1-19 | 1 | 6800 Ω 1/2 watt (blue-gray-red) |
| 1-22 | 1 | 22 KΩ 1/2 watt (red-red-orange) |
| 1-23 | 4 | 27 KΩ 1/2 watt (red-violet-orange) |
| 1-25 | 6 | 47 KΩ 1/2 watt (yellow-violet-orange) |
| 1-29 | 2 | 220 KΩ 1/2 watt (red-red-yellow) |
| 1-32 | 2 | 390 KΩ 1/2 watt (orange-white-yellow) |
| 1-33 | 7 | 470 KΩ 1/2 watt (yellow-violet-yellow) |
| 1-35 | 4 | 1 megohm 1/2 watt (brown-black-green) |
| 1-39 | 1 | 4.7 megohm 1/2 watt (yellow-violet-green) |
| 1A-28 | 2 | 100 KΩ 1 watt (brown-black-yellow) |
| 1A-34 | 1 | 1 megohm 1 watt (brown-black-green) |
| 1B-1 | 1 | 2700 Ω 2 watt (red-violet-red) |
| 1B-10 | 1 | 47 KΩ 2 watt (yellow-violet-orange) |
| 2B-6 | 2 | 2 megohm 2 watt (precision) |

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| **Controls-Switches** | | |
| 10-32 | 2 | 1 megohm linear |
| 10-60 | 1 | 500 KΩ linear, tab mounting |
| 10-94 | 1 | 7.5 megohm linear |
| 10-96 | 1 | 1 megohm linear on insulated bushing |
| 19-55 | 1 | 20 KΩ linear with push-pull switch |
| 60-1 | 1 | 2-lug slide switch |
| 63-239 | 1 | 6-position rotary with ON-OFF switch |
| **Capacitors** | | |
| 21-14 | 5 | .001 μfd disc ceramic |
| 21-16 | 5 | .01 μfd disc ceramic |
| 21-26 | 1 | .003 μfd disc ceramic |
| 21-48 | 3 | .05 μfd disc ceramic |
| 21-75 | 1 | 100 μμf disc ceramic |
| 23-28 | 1 | .1 μfd tubular |
| 23-34 | 1 | .01 μfd tubular |
| 23-77 | 1 | .1 and .2 μfd paper (metal can) |
| 25-21 | 1 | 20-20-20-20 μfd, 450 volt electrolytic |
| 25-41 | 2 | 40 μfd 350 volt electrolytic |
| 27-4 | 1 | .2 μfd mylar |
| **Transformer-Coils** | | |
| 40-336 | 1 | Pickup coil |
| 45-35 | 1 | 1.7 μh choke coil |
| 54-108 | 1 | Power transformer |
| **Terminal Strips-Sockets-Knobs** | | |
| 431-3 | 1 | 3-lug terminal strip (no ground) |
| 431-10 | 1 | 3-lug terminal strip |
| 431-35 | 1 | 7-lug terminal strip |
| 431-39 | 1 | 5-lug miniature terminal strip |
| 431-42 | 1 | 5-lug terminal strip |

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| **Terminal Strips-Sockets-Knobs (Cont'd.)** | | |
| 431-45 | 2 | 6-lug terminal strip |
| 432-23 | 1 | 4-lug connector socket |
| 432-24 | 1 | 4-lug connector plug |
| 434-16 | 5 | 9-pin wafer tube socket |
| 434-58 | 1 | Octal socket |
| 434-68 | 1 | 9-pin molded tube socket |
| 462-52 | 4 | Black knob with pointer |
| 462-82 | 2 | Black knob (small) |
| **Wire-Cable-Sleeving** | | |
| 89-15 | 1 | Line cord |
| 134-23 | 1 | Cable harness and tube socket |
| 341-1 | 1 | Length black test lead |
| 341-2 | 1 | Length red test lead |
| 343-3 | 1 | Length single-conductor shielded wire |
| 344-1 | 1 | Length hookup wire |
| 346-1 | 1 | Length sleeving |
| 347-19 | 1 | Length 3-conductor shielded cable |
| **Metal Parts** | | |
| 90-148 | 1 | Cabinet |
| 100-M292 | 1 | CR tube shield |
| 200-M271F387 | 1 | Main chassis |
| 203-209F347 | 1 | Front panel |
| 204-M236 | 1 | CR tube shield bracket |
| 204-M339 | 1 | CR tube support bracket |
| 204-M351 | 1 | High voltage supply chassis |
| 205-M242 | 1 | Shield plate |
| 207-M1 | 2 | CR tube neck clamp |
| 210-13F | 1 | Bezel |
| **Hardware** | | |
| 250-13 | 2 | 6-32 x 1" RHMS |
| 250-18 | 4 | 8-32 x 3/8" RHMS |
| 250-49 | 13 | 3-48 x 1/4" screw |
| 250-83 | 2 | #10 x 1/2" sheet metal screw |
| 250-89 | 33 | 6-32 x 3/8" screw |
| 250-133 | 1 | 3-48 x 7/16" screw |
| 250-186 | 3 | 4-24 self-tapping screw |
| 252-1 | 14 | 3-48 nut |
| 252-3 | 23 | 6-32 nut |
| 252-4 | 4 | 8-32 nut |
| 252-7 | 6 | Control nut |
| 252-10 | 1 | Small push on speednut |
| 252-22 | 14 | #6 speednut |
| 252-32 | 1 | Large push on speednut |
| 252-34 | 4 | Knurled thumbnut |

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| **Hardware (Cont'd.)** | | |
| 253-9 | 4 | #8 flat steel washer |
| 253-10 | 6 | Control flat washer |
| 253-39 | 4 | Bezel mounting washer |
| 254-1 | 26 | #6 lockwasher |
| 254-2 | 4 | #8 lockwasher |
| 254-4 | 4 | Control lockwasher |
| 254-7 | 13 | #3 lockwasher |
| 255-29 | 1 | #3 spacer |
| 258-42 | 1 | Spark pickup clamp trigger spring |
| 259-1 | 1 | #6 solder lug |
| 259-10 | 2 | Control solder lug |
| 427-7 | 4 | Binding post base |
| **Tubes-Rectifiers-Lamps** | | |
| 57-23 | 3 | Silicon rectifier (red end) |
| 57-27 | 1 | Silicon rectifier |
| 411-25 | 2 | 12AU7 tube |
| 411-26 | 2 | 12AX7 tube |
| 411-49 | 1 | 5UP1 CR tube |
| 411-65 | 1 | 1V2 tube |
| 411-124 | 1 | 6EA8 tube |
| 412-13 | 1 | Red neon pilot lamp |
| **Miscellaneous** | | |
| 73-1 | 2 | 3/8" rubber grommet |
| 73-2 | 2 | 3/4" rubber grommet |
| 73-3 | 2 | 1/2" rubber grommet |
| 73-5 | 1 | Rubber cushion strip |
| 73-11 | 2 | Red test clip insulator |
| 73-12 | 1 | Black test clip insulator |
| 73-M16 | 1 | Adhesive rubber gasket |
| 75-29 | 1 | Line cord strain relief |
| 95-7 | 1 | Spark pickup clamp shell |
| 95-8 | 1 | Spark pickup clamp cover |
| 100-M293 | 1 | Spark pickup clamp trigger |
| 207-5 | 2 | 3/16" cable clamp |
| 207-35 | 1 | Cable grip |
| 211-15 | 1 | Handle |
| 260-14 | 2 | Test clip |
| 260-21 | 1 | Ignition pickup clip |
| 261-9 | 4 | Rubber feet |
| 414-10F349 | 1 | Plastic grid screen plate |
| 414-M6 | 1 | Green filter |
| 421-20 | 2 | 1/2 ampere slow-blow fuse (1 spare) |
| 423-1 | 1 | Fuse holder |
| 432-27 | 1 | Plug adapter |
| 481-1 | 1 | Capacitor mounting wafer |
| 595-245 | 1 | Application manual |
| 595-361 | 1 | Construction manual |

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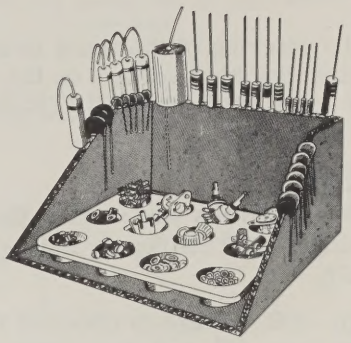

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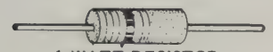
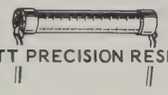
| 1-25 | 6 | 47 KΩ 1/2 watt (yellow-violet-orange) |
| 1-29 | 2 | 220 KΩ 1/2 watt (red-red-yellow) |
| 1-32 | 2 | 390 KΩ 1/2 watt (orange-white-yellow) |
| 1-33 | 7 | 470 KΩ 1/2 watt (yellow-violet-yellow) |
| 1-35 | 4 | 1 megohm 1/2 watt (brown-black-green) |
| 1-39 | 1 | 4.7 megohm 1/2 watt (yellow-violet-green) |
| 1A-28 | 2 | 100 KΩ 1 watt (brown-black-yellow) |
| 1A-34 | 1 | 1 megohm 1 watt (brown-black-green) |
| 1B-1 | 1 | 2700 Ω 2 watt (red-violet-red) |
| 1B-10 | 1 | 47 KΩ 2 watt (yellow-violet-orange) |
| 2B-6 | 2 | 2 megohm 2 watt (precision) |

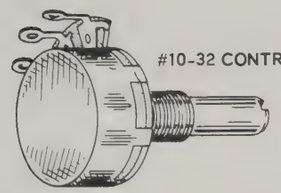
| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| **Controls-Switches** | | |
| 10-32 | 2 | 1 megohm linear |
| 10-60 | 1 | 500 KΩ linear, tab mounting |
| 10-94 | 1 | 7.5 megohm linear |
| 10-96 | 1 | 1 megohm linear on insulated bushing |
| 19-55 | 1 | 20 KΩ linear with push-pull switch |
| 60-1 | 1 | 2-lug slide switch |
| 63-239 | 1 | 6-position rotary with ON-OFF switch |
| **Capacitors** | | |
| 21-14 | 5 | .001 μfd disc ceramic |
| 21-16 | 5 | .01 μfd disc ceramic |
| 21-26 | 1 | .003 μfd disc ceramic |
| 21-48 | 3 | .05 μfd disc ceramic |
| 21-75 | 1 | 100 μμf disc ceramic |
| 23-28 | 1 | .1 μfd tubular |
| 23-34 | 1 | .01 μfd tubular |
| 23-77 | 1 | .1 and .2 μfd paper (metal can) |
| 25-21 | 1 | 20-20-20-20 μfd, 450 volt electrolytic |
| 25-41 | 2 | 40 μfd 350 volt electrolytic |
| 27-4 | 1 | .2 μfd mylar |
| **Transformer-Coils** | | |
| 40-336 | 1 | Pickup coil |
| 45-35 | 1 | 1.7 μh choke coil |
| 54-108 | 1 | Power transformer |
| **Terminal Strips-Sockets-Knobs** | | |
| 431-3 | 1 | 3-lug terminal strip (no ground) |
| 431-10 | 1 | 3-lug terminal strip |
| 431-35 | 1 | 7-lug terminal strip |
| 431-39 | 1 | 5-lug miniature terminal strip |
| 431-42 | 1 | 5-lug terminal strip |

1/2 WATT RESISTOR

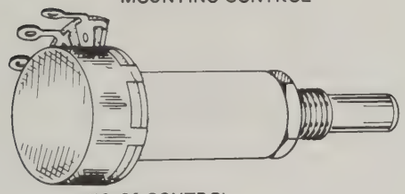

1 WATT RESISTOR

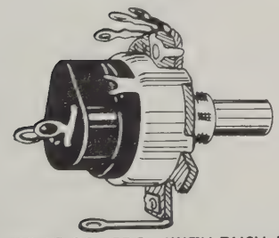
2 WATT RESISTOR

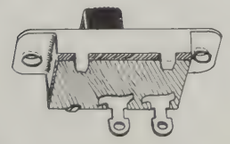

2 WATT PRECISION RESISTOR


#10-32 CONTROL

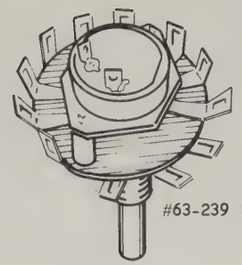
#10-60 500 KΩ TAB MOUNTING CONTROL


#10-96 CONTROL

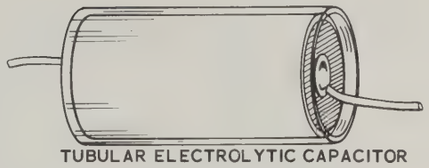

#19-55 CONTROL WITH PUSH-PULL SWITCH

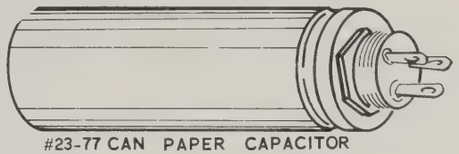

#60-1 2-LUG SLIDE SWITCH

3-LUG TERMINAL STRIP

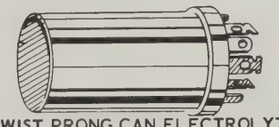

#63-239 ROTARY SWITCH

DISC CERAMIC CAPACITOR

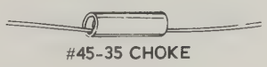

TUBULAR ELECTROLYTIC CAPACITOR


#23-77 CAN PAPER CAPACITOR

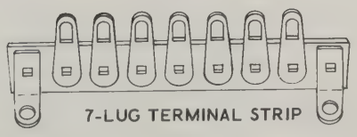
TUBULAR CAPACITOR


TWIST PRONG CAN ELECTROLYTIC CAPACITOR

PICKUP COIL
#40-336


#45-35 CHOKE

3-LUG TERMINAL STRIP

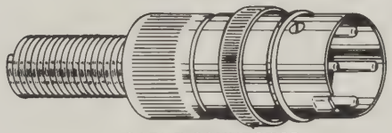

7-LUG TERMINAL STRIP

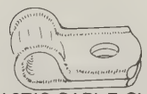
5-LUG TERMINAL STRIP

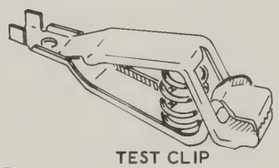
5-LUG MINIAUTRE TERMINAL STRIP

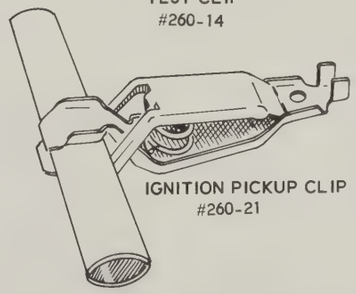
6-LUG TERMINAL STRIP

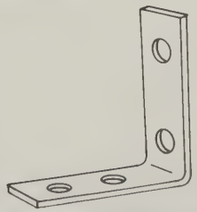
CONNECTOR SOCKET


CABLE CONNECTOR

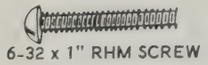

PLASTIC CABLE CLAMP


TEST CLIP
#260-14


IGNITION PICKUP CLIP
#260-21

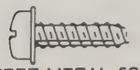

CR TUBE SHIELD MOUNTING BRACKET

CR TUBE NECK CLAMP


6-32 x 1" RHM SCREW

8-32 x 3/8" RHM SCREW

3-48 x 1/4" SCREW


#10 SHEET METAL SCREW

6-32 x 3/8" SCREW

3-48 x 7/16" SCREW

4-24 SELF-TAPPING SCREW

3-48 NUT

6-32 NUT

8-32 NUT

CONTROL NUT

#6 SPEEDNUT

SMALL PUSH-ON SPEEDNUT

LARGE PUSH-ON SPEEDNUT

KNURLED THUMBNUT

#8 FLAT STEEL WASHER

CONTROL FLAT WASHER

BEZEL MOUNTING WASHER

#3 LOCKWASHER

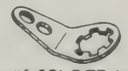
#6 LOCKWASHER

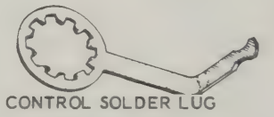
#8 LOCKWASHER

CONTROL LOCKWASHER


#3 SPACER

TRIGGER SPRING


#6 SOLDER LUG


CONTROL SOLDER LUG

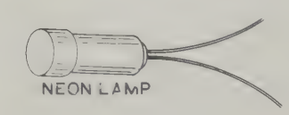
BINDING POST BASE

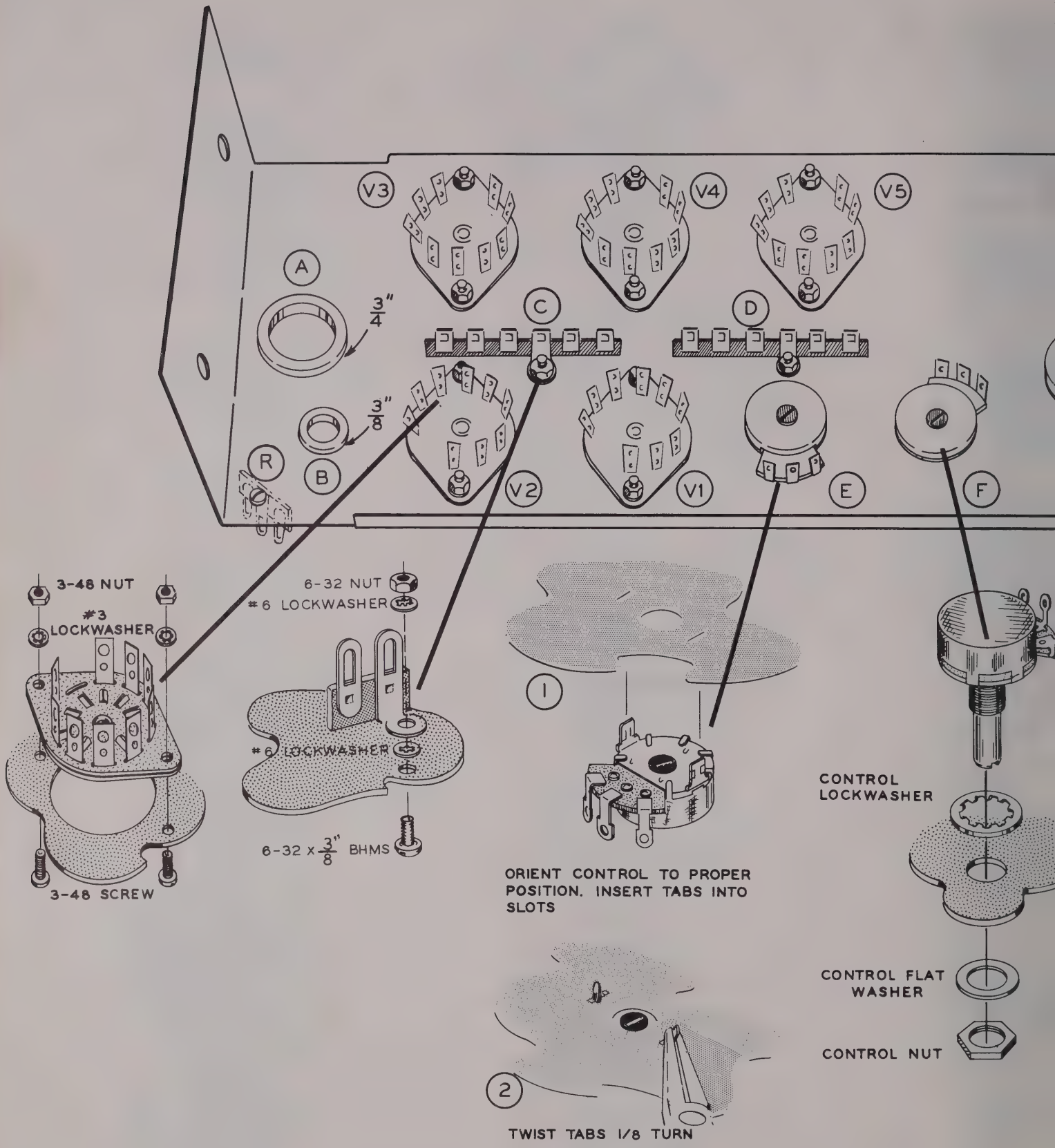
YELLOW DOT

#57-29 SILICON DIODE

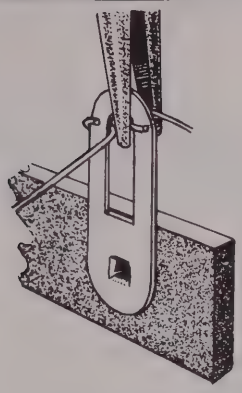
RED DOT

#57-23 SILICON DIODE

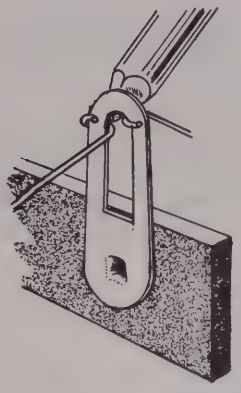

NEON LAMP


V3
V4
V5
A
3/4"
C
D
3/8"
R
B
V2
V1
E
F
3-48 NUT
#3 LOCKWASHER
3-48 SCREW
6-32 NUT
#6 LOCKWASHER
#6 LOCKWASHER
6-32 x 3/8" BHMS
1
ORIENT CONTROL TO PROPER POSITION. INSERT TABS INTO SLOTS
CONTROL LOCKWASHER
CONTROL FLAT WASHER
CONTROL NUT
2
TWIST TABS 1/8 TURN

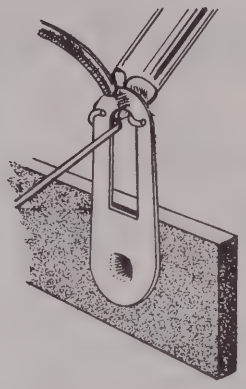
Pictorial 1



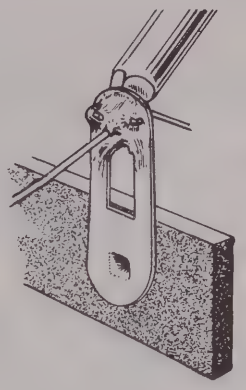
CRIMP WIRES



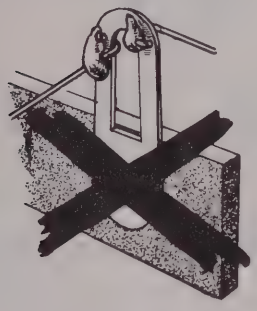
HEAT CONNECTION



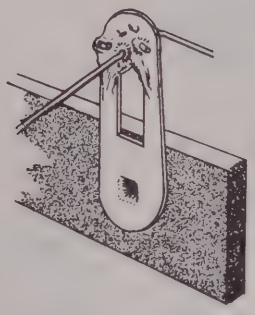
APPLY SOLDER



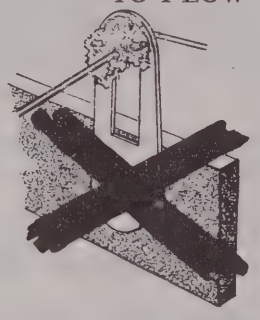
ALLOW SOLDER TO FLOW



COLD SOLDER JOINT CONNECTION INSUFFICIENTLY HEATED



PROPER SOLDER CONNECTION



COLD SOLDER JOINT CONNECTION MOVED WHILE COOLING

## STEP-BY-STEP PROCEDURE

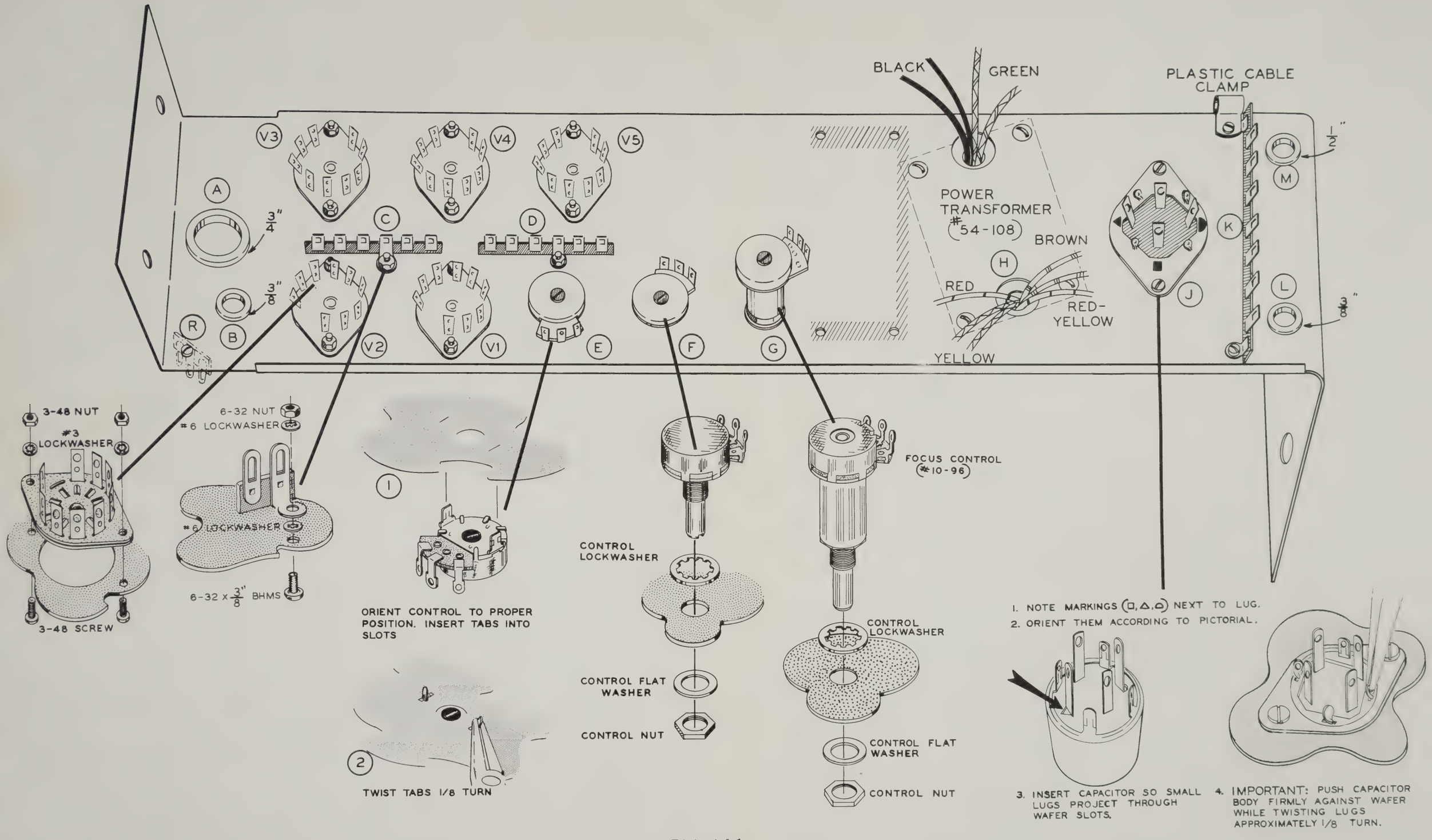
The following instructions are presented in a logical step-by-step sequence to enable you to complete your kit with the least possible confusion. Be sure to read each step all the way through before beginning the specified operation. Also read several steps ahead of the actual step being performed. This will familiarize you with the relationship of the subsequent operations. When the step is completed, check it off in the space provided. This is particularly important as it may prevent errors or omissions, especially if your work is interrupted. Some kit builders have also found it helpful to mark each lead in colored pencil on the Pictorial as it is added.

The fold-out diagrams in this manual may be removed and attached to the wall above your working area; but, because they are an integral part of the instructions, they should be returned to the manual after the kit is completed.

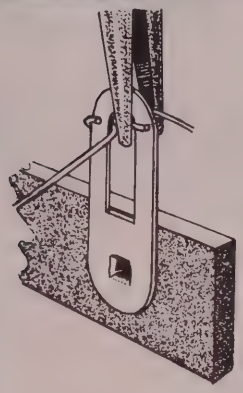
In general, the illustrations in this manual correspond to the actual configuration of the kit; however, in some instances the illustrations may be slightly distorted to facilitate clearly showing all of the parts.

The abbreviation "NS" indicates that a connection should not be soldered yet as other wires will be added. When the last wire is installed, the terminal should be soldered and the abbreviation "S" is used to indicate this. Note that a number will appear after each solder instruction. This number indicates the number of leads that are supposed to be connected to the terminal in point before it is soldered. For example, if the instruction reads, "Connect a lead to lug 1 (S-2)," it will be understood that there will be two leads connected to the terminal at the time it is soldered. (In cases where a lead passes through a terminal or lug and then connects to another point, it will count as two leads, one entering and one leaving the terminal.)

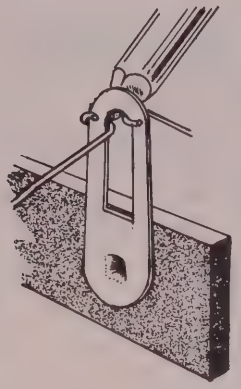
The steps directing the installation of resistors include color codes to help identify the parts. Also, if a part is identified by a letter-number designation on the Schematic, its designation will appear in the construction step which directs its installation.


BLACK
GREEN
PLASTIC CABLE CLAMP
POWER TRANSFORMER (#54-108)
BROWN
RED
RED-YELLOW
YELLOW
V1
V2
V3
V4
V5
A
B
C
D
E
F
G
H
J
K
L
M
R
3/4"
3/8"
1/2"
3/8"
3-48 NUT
#3 LOCKWASHER
3-48 SCREW
6-32 NUT
#6 LOCKWASHER
#6 LOCKWASHER
6-32 x 3/8" BHMS
ORIENT CONTROL TO PROPER POSITION. INSERT TABS INTO SLOTS
TWIST TABS 1/8 TURN
CONTROL LOCKWASHER
CONTROL FLAT WASHER
CONTROL NUT
FOCUS CONTROL (#10-96)
CONTROL LOCKWASHER
CONTROL FLAT WASHER
CONTROL NUT
1. NOTE MARKINGS (□, △, ⌓) NEXT TO LUG.
2. ORIENT THEM ACCORDING TO PICTORIAL.
3. INSERT CAPACITOR SO SMALL LUGS PROJECT THROUGH WAFER SLOTS.
4. IMPORTANT: PUSH CAPACITOR BODY FIRMLY AGAINST WAFER WHILE TWISTING LUGS APPROXIMATELY 1/8 TURN.

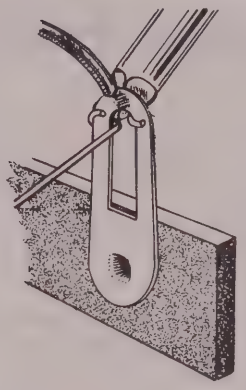
Pictorial 1



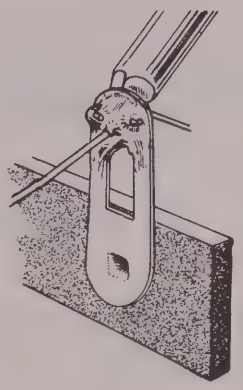
CRIMP WIRES



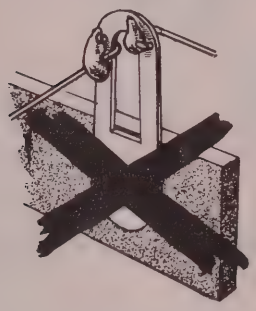
HEAT CONNECTION



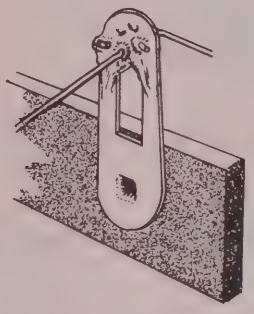
APPLY SOLDER



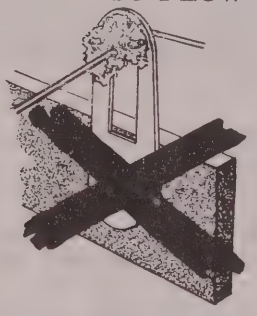
ALLOW SOLDER TO FLOW



COLD SOLDER JOINT CONNECTION INSUFFICIENTLY HEATED



PROPER SOLDER CONNECTION



COLD SOLDER JOINT CONNECTION MOVED WHILE COOLING

## STEP-BY-STEP PROCEDURE

The following instructions are presented in a logical step-by-step sequence to enable you to complete your kit with the least possible confusion. Be sure to read each step all the way through before beginning the specified operation. Also read several steps ahead of the actual step being performed. This will familiarize you with the relationship of the subsequent operations. When the step is completed, check it off in the space provided. This is particularly important as it may prevent errors or omissions, especially if your work is interrupted. Some kit builders have also found it helpful to mark each lead in colored pencil on the Pictorial as it is added.

The fold-out diagrams in this manual may be removed and attached to the wall above your working area; but, because they are an integral part of the instructions, they should be returned to the manual after the kit is completed.

In general, the illustrations in this manual correspond to the actual configuration of the kit; however, in some instances the illustrations may be slightly distorted to facilitate clearly showing all of the parts.

The abbreviation "NS" indicates that a connection should not be soldered yet as other wires will be added. When the last wire is installed, the terminal should be soldered and the abbreviation "S" is used to indicate this. Note that a number will appear after each solder instruction. This number indicates the number of leads that are supposed to be connected to the terminal in point before it is soldered. For example, if the instruction reads, "Connect a lead to lug 1 (S-2)," it will be understood that there will be two leads connected to the terminal at the time it is soldered. (In cases where a lead passes through a terminal or lug and then connects to another point, it will count as two leads, one entering and one leaving the terminal.)

The steps directing the installation of resistors include color codes to help identify the parts. Also, if a part is identified by a letter-number designation on the Schematic, its designation will appear in the construction step which directs its installation.

# STEP-BY-STEP ASSEMBLY

## MECHANICAL ASSEMBLY

Refer to Pictorial 1 for the following steps.

( ) Position the main chassis as shown in Pictorial 1.

( ) Referring to the Detail, mount 9-pin wafer tube socket V2. Use 3-48 screws, #3 lockwashers, and 3-48 nuts. Orient the blank space as shown.

( ) Similarly, mount tube sockets V1, V3, V4 and V5. Be sure to orient the blank spaces as shown.

( ) Install the rubber grommets in holes A, B, L, and M.

NOTE: The phrase "#6 hardware" means 6-32 screws, #6 lockwashers, and 6-32 nuts.

( ) Mount a 6-lug terminal strip at location C. Use #6 hardware. See Detail.

( ) Similarly, mount a 6-lug terminal strip at location D. Use #6 hardware.

( ) Mount a 3-lug (center grounded) terminal strip at location R on the opposite side of the chassis. Use #6 hardware.

( ) Mount the 7-lug terminal strip at location K. Fasten a plastic cable clamp under one of the mounting lugs. Use #6 hardware. Do not tighten the screw holding the plastic cable clamp. Do not use lockwashers under mounting feet.

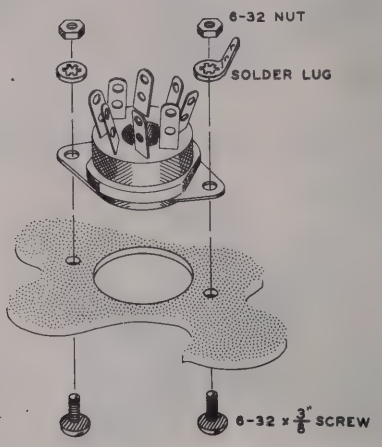
( ) R2. Mount the 500 KΩ control (#10-60) at location E. Secure the control by twisting each tab 1/8 turn with long-nose pliers. See Detail.

( ) R39. Mount the 1 megohm control (#10-32) at F. Use a control lockwasher, control flat washer, and control nut. See Detail.

( ) R42. Similarly, mount the 1 megohm control (#10-96) at G. See Detail.

( ) Mount the power transformer. Use 8-32 screws, #8 lockwashers, and 8-32 nuts. Place the transformer so that the large wires pass through hole H.

( ) Referring to Detail 1A, mount the 8-pin octal accessory power socket and a #6 solder lug at location N. Make sure that the keyway in the socket is as shown. (Refer also to Pictorial 9 on Page 20.




Detail 1A

( ) Mount the electrolytic capacitor mounting wafer on the bottom of the chassis at J. See Detail. Use #6 hardware.

( ) C21. Mount the 4-section electrolytic capacitor on the wafer. Position the lugs as shown and secure the capacitor by twisting the mounting tabs 1/8 turn with long-nose pliers.

## POWER SUPPLY WIRING

Refer to Pictorial 2 for the following steps.

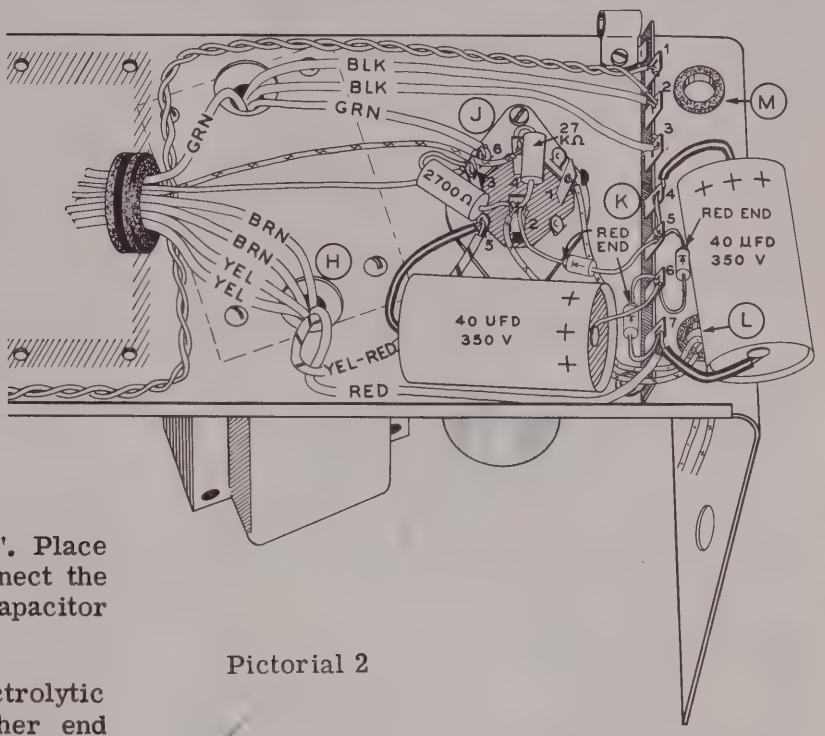
( ) Connect the short green wire, coming from the power transformer, to lug 6 of electrolytic capacitor J (S-1). Apply enough solder to secure the mounting lug to the mounting wafer.

( ) Connect either of the black wires, coming from the power transformer, to lug 2 of terminal strip K (NS).

( ) Connect the other black wire to lug 3 of terminal strip K (NS).

( ) Connect the red wire coming from hole H to lug 7 of terminal strip K (NS).

( ) Connect the red-yellow wire coming from hole H to lug 5 of electrolytic capacitor J (NS).




Pictorial 2

(✓) Strip one end of a 5" wire 1/2". Place this end through grommet L. Connect the other end to lug 2 of electrolytic capacitor J (NS).

(✓) Connect a 5" wire to lug 1 of electrolytic capacitor J (S-1). Place the other end through grommet L to be connected later.

(✓) Connect a 6-1/2" wire to lug 3 of electrolytic capacitor J (NS). Leave the other end free.

(✓) Connect a 9" wire to lug 4 of electrolytic capacitor J (NS). Leave the other end free.

(✓) Twist two 20-1/2" wires together and strip 1/4" of insulation from each end of each wire.

(✓) Connect either of the two wires to lug 1 of terminal strip K (NS).

(✓) Connect the other wire to lug 2 of terminal strip K (S-2). Dress the twisted wires toward the front of the chassis as shown in Pictorial 2 and place through grommet B.

(✓) R44. Connect a 27 KΩ (red-violet-orange) resistor between lugs 2 (NS) and 4 (S-2) of electrolytic capacitor J.

(✓) R43. Connect a 2700 Ω (red-violet-red) 2 watt resistor between lugs 2 (NS) and 3 (S-2) of electrolytic capacitor J.

(✓) D2. Connect the red positive (→|+) lead of a silicon diode to lug 5 of terminal strip K (NS). Connect the other lead to lug 6 of K (NS).

(✓) D1. Connect the red positive (→|+) lead of a silicon diode to lug 6 of terminal strip K (NS). Connect the other lead to lug 7 of K (NS).

(✓) D3. Connect the red positive (→|+) lead of another silicon diode to lug 2 of electrolytic capacitor J (S-4). Connect the other lead to lug 5 of terminal strip K (NS).

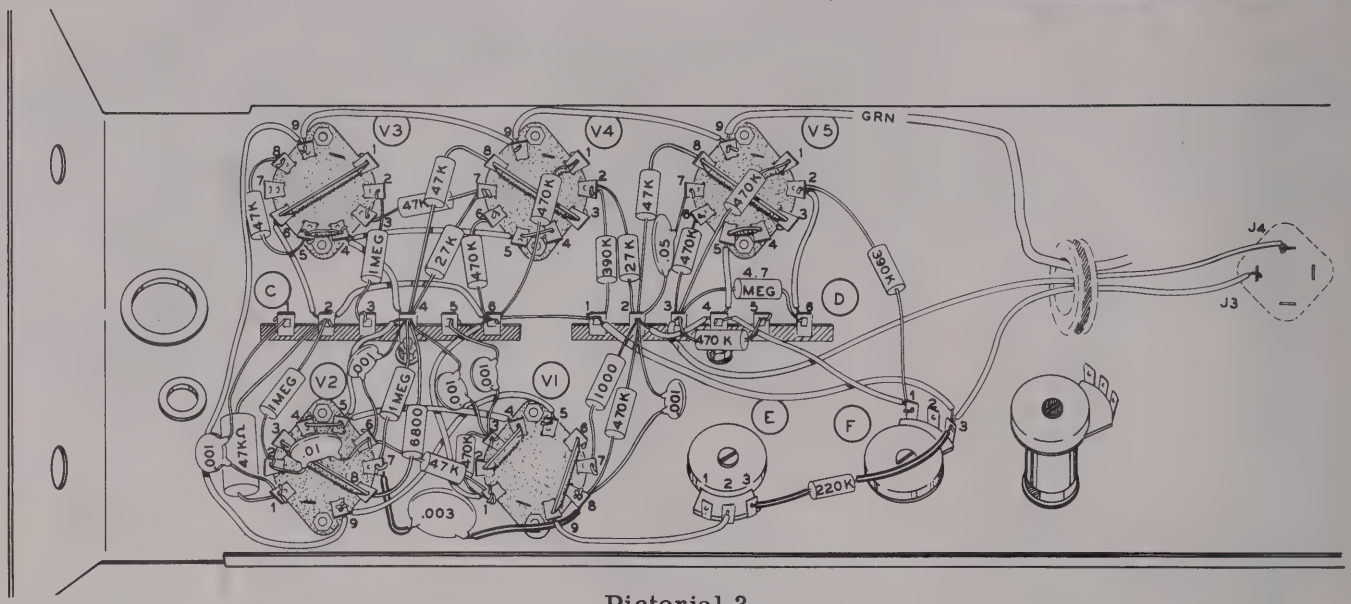
(✓) C19. Connect the positive (+) lead of a 40 µfd 350 volt tubular electrolytic capacitor to lug 6 of terminal strip K (S-3).

(✓) C19. Connect the other lead of this capacitor to lug 5 of electrolytic capacitor J (S-2). Use sleeving.

(✓) C20. Connect the positive (+) lead of another 40 µfd 350 volt tubular electrolytic capacitor through lug 4 (NS) to lug 5 (S-3) of terminal strip K. Use sleeving. Now, solder lug 4 of K (S-2).

(✓) Connect the other lead of this capacitor to lug 7 of terminal strip K (S-3). Use sleeving.

(✓) Place a 3/4" rubber grommet over the two large yellow, two large brown and the one green power transformer leads. Place the two wires, extending from lugs 3 and 4 of electrolytic capacitor J, through the 3/4" rubber grommet.




Pictorial 3

## MAIN CHASSIS WIRING

Refer to Pictorial 3 for the following steps.

( ) Connect the wire coming from lug 3 of electrolytic capacitor J to lug 3 of control F(NS).

( ) Connect the wire coming from lug 4 of electrolytic capacitor J to lug 3 of terminal strip D (NS).

( ) Connect the green power transformer lead to lug 9 of tube socket V5 (NS).

( ) Connect a 4" wire from lug 3 of control F (NS) to lug 1 of terminal strip D (NS).

( ) Connect a 2" wire from lug 1 of control F (NS) to lug 4 of terminal strip D (NS).

( ) Connect a 2" wire between lugs 2 (NS) and 4 (NS) of terminal strip D.

( ) Strip one end of a 3" wire 1" and connect this end through lug 9 (NS) to lug 6 (S-1) of tube socket V1. Now, solder lug 9 of V1 (S-2). Connect the other end of this wire to lug 2 of control E (S-1).

( ) Connect a 3" wire from lug 5 of tube socket V1 (S-1) to lug 9 of tube socket V2 (NS).

( ) Strip one end of a 2-1/2" wire 3/4" and connect it through lug 4 (NS) to lug 2 (S-1) of tube socket V1. Now, solder lug 4 of V1 (S-2). Connect the other end of this wire to lug 5 of tube socket V2 (NS).

( ) Connect a 2-1/2" wire from lug 1 of tube socket V1 (NS) to lug 6 of terminal strip C (NS).

( ) Strip one end of a 2" wire 1/2" and connect it through lug 5 (NS) to lug 4 (S-1) of tube socket V2. Now, solder lug 5 of V2 (S-3). Connect the other end of this wire to lug 4 of terminal strip C (NS).

( ) Connect a 4-1/2" wire from lug 9 of tube socket V2 (S-2) to lug 9 of tube socket V3 (NS).

( ) Strip one end of a 2" wire 1" and connect it through lug 6 (NS) to lug 1 (S-1) of tube socket V3. Now, solder lug 6 of V3 (S-2). Connect the other end of this wire to lug 2 of terminal strip C (NS).

( ) Connect a 2-1/2" wire between lugs 2 (NS) and 6 (NS) of terminal strip C.

( ) Strip one end of a 1-1/2" wire 1/2" and connect it through lug 4 (NS) to lug 5 (NS) of tube socket V3. Connect the other end of this wire to lug 4 of terminal strip C (NS).

( ) Connect a 2-1/2" wire from lug 9 of tube socket V3 (S-2) to lug 9 of tube socket V4 (NS).

( ) Connect a 2-1/2" wire from lug 9 of tube socket V4 (S-2) to lug 9 of tube socket V5 (NS).

( ) Strip one end of a 2" wire 1/2" and connect it through lug 5 (NS) to lug 4 (S-1) of tube socket V4. Now solder lug 5 (S-2). Connect the other end of this wire to lug 4 of tube socket V3 (S-3).

( ) Connect a 2" wire from lug 2 of tube socket V5 (NS) to lug 6 of terminal strip D (NS).

( ) Strip one end of a 1-1/2" wire 1/2" and connect it through lug 5 (NS) to lug 4 (S-1) of tube socket V5. Now, solder lug 5 of V5 (S-2). Connect the other end of this wire to lug 4 of terminal strip D (NS).

( ) R3. Connect a 220 KΩ (red-red-yellow) resistor from lug 3 of control E (S-1) to lug 3 of control F (S-3). Use sleeving.

( ) R31. Connect a 470 KΩ (yellow-violet-yellow) resistor between lugs 3 (NS) and 5 (NS) of terminal strip D.

( ) R33. Connect a 390 KΩ (orange-white-yellow) resistor from lug 1 of control F (S-2) to lug 2 of tube socket V5 (S-2).

( ) R28. Connect a 4.7 megohm (yellow-violet-green) resistor between lugs 3 (NS) and 6 (NS) of terminal strip D.

( ) R34. Connect one lead of a 47 KΩ (yellow-violet-orange) resistor through lug 8 (NS) to lug 3 (S-1) of tube socket V5. Now, solder lug 8 of V5 (S-2). Connect the other lead to lug 2 of terminal strip D (NS).

( ) R29. Connect a 470 KΩ (yellow-violet-yellow) resistor from lug 1 of tube socket V5 (NS) to lug 3 of terminal strip D (NS).

( ) R30. Connect a 470 KΩ (yellow-violet-yellow) resistor from lug 6 of tube socket V5 (NS) to lug 3 of terminal strip D (S-5).

( ) R21. Connect a 390 KΩ (orange-white-yellow) resistor from lug 1 of terminal strip D (NS) to lug 2 of tube socket V4 (NS).

( ) R18. Connect a 27 KΩ (red-violet-orange) resistor from lug 2 of terminal strip D (NS), to lug 2 of tube socket V4 (S-2).

( ) R1. Connect a 1000 Ω (brown-black-red) resistor from lug 2 of terminal strip D (NS) to lug 7 of tube socket V1 (NS).

( ) R5. Connect a 470 KΩ (yellow-violet-yellow) resistor from lug 2 of terminal strip D (NS) to lug 8 of tube socket V1 (NS).

( ) C7. Connect a .001 μfd disc ceramic capacitor from lug 2 of terminal strip D (NS) to lug 8 of tube socket V1 (NS).

( ) C18. Connect a .05 μfd disc ceramic capacitor from lug 2 of terminal strip D (S-7) to lug 7 of tube socket V5 (NS).

( ) C8. Connect a .003 μfd disc ceramic capacitor from lug 8 of tube socket V1 (S-3) to lug 7 of tube socket V2 (NS). Use sleeving on both leads.

( ) R4. Connect a 470 KΩ (yellow-violet-yellow) resistor between lugs 1 (NS) and 3 (NS) of tube socket V1.

( ) R7. Connect a 47 KΩ (yellow-violet-orange) resistor from lug 1 of tube socket V1 (S-3) to lug 6 of tube socket V2 (NS).

( ) R10. Connect one end of a 6800 Ω (blue-gray-red) resistor through lug 8 (NS) to lug 3 (S-1) of tube socket V2. Now solder lug 8 (S-2). Connect the other end of this resistor to lug 4 of terminal strip C (NS).

( ) R6. Connect a 1 megohm (brown-black-green) resistor from lug 7 of tube socket V2 (S-2) to lug 4 of terminal strip C (NS).

( ) C6. Connect a .001 μfd disc ceramic capacitor from lug 3 of tube socket V1 (NS) to lug 4 of terminal strip C (NS).

( ) C5. Connect a .001 μfd disc ceramic capacitor from lug 3 of tube socket V1 (S-3) to lug 5 of terminal strip C (NS).

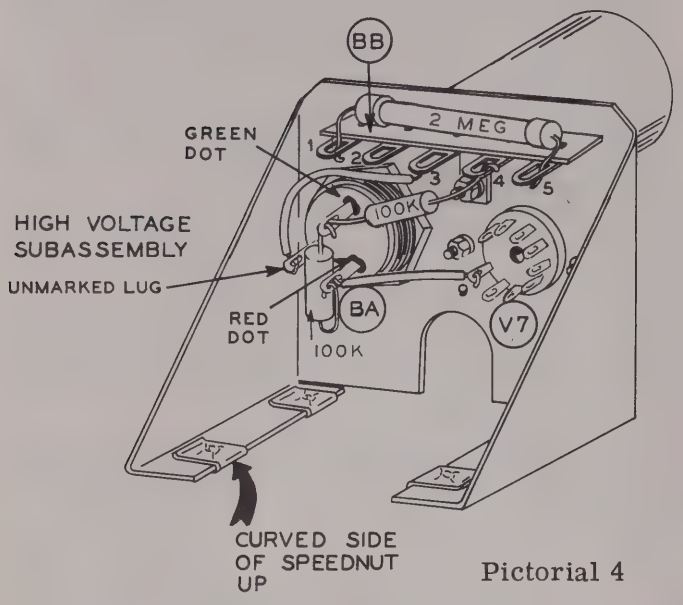
( ) C9. Connect a .001 μfd disc ceramic capacitor from lug 6 of tube socket V2 (NS) to lug 4 of terminal strip C (NS).

( ) R7. Connect a 47 KΩ (yellow-violet-orange) 2 watt resistor from lug 1 of tube socket V2 (NS) to lug 2 of terminal strip C (NS).

( ) C11. Connect a .001 μfd capacitor from lug 1 of tube socket V2 (S-2) to lug 1 of terminal strip C (NS).

( ) R8. Connect a 1 megohm (brown-black-green) resistor from lug 2 of tube socket V2 (NS) to lug 2 of terminal strip C (S-4).

( ) C10. Connect a .01 μfd disc ceramic capacitor between lugs 2 (S-2) and 6 (S-3) of tube socket V2.




Pictorial 4

(✓) R13. Connect a 47 KΩ (yellow-violet-orange) resistor between lugs 5 (S-2) and 8 (NS) of tube socket V3.

(✓) R15. Connect a 47 KΩ (yellow-violet-orange) resistor from lug 3 of tube socket V3 (NS) to lug 7 of tube socket V4 (NS).

(✓) R16. Connect a 27 KΩ (red-violet-orange) resistor from lug 7 of tube socket V4 (S-2) to lug 4 of terminal strip C (NS).

(✓) R17. Connect one lead of a 47 KΩ (yellow-violet-orange) resistor through lug 8 (NS) to lug 3 (S-1) of tube socket V4. Now, solder lug 8 of V4 (S-2). Connect the other lead to lug 4 of terminal strip C (S-8).

(✓) R14. Connect a 1 megohm (brown-black-green) resistor from lug 2 of tube socket V3 (NS) to lug 3 of terminal strip C (NS).

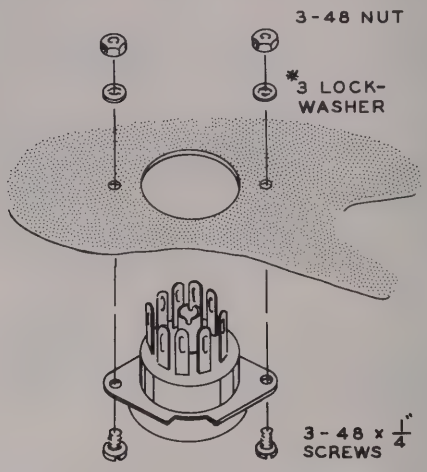
(✓) R20. Connect a 470 KΩ (yellow-violet-yellow) resistor from lug 1 of tube socket V4 (NS) to lug 6 of terminal strip C (NS).

(✓) Connect one end of a 470 KΩ (yellow-violet-yellow) resistor through lug 6 of terminal strip C (NS) to lug 1 of terminal strip D (S-3). Connect the other lead to lug 6 of tube socket V4 (NS). Now solder lug 6 of terminal strip C (S-5).

This completes the wiring on the main chassis at this time. Set this subassembly aside.

## HIGH VOLTAGE SUBASSEMBLY

(✓) Locate the High Voltage Subassembly bracket and position it as shown in Pictorial 4.




Detail 4A

(✓) Referring to Detail 4A, mount the 9-pin molded tube socket at V7. Be sure to orient the blank space as shown in Pictorial 4. Use 3-48 x 1/4" screws, #3 lockwashers, and 3-48 nuts.

(✓) Mount the High Voltage Filter capacitor at BA. Use the mounting nut that is supplied with the capacitor. Be sure to orient the lugs as shown in Pictorial 4.

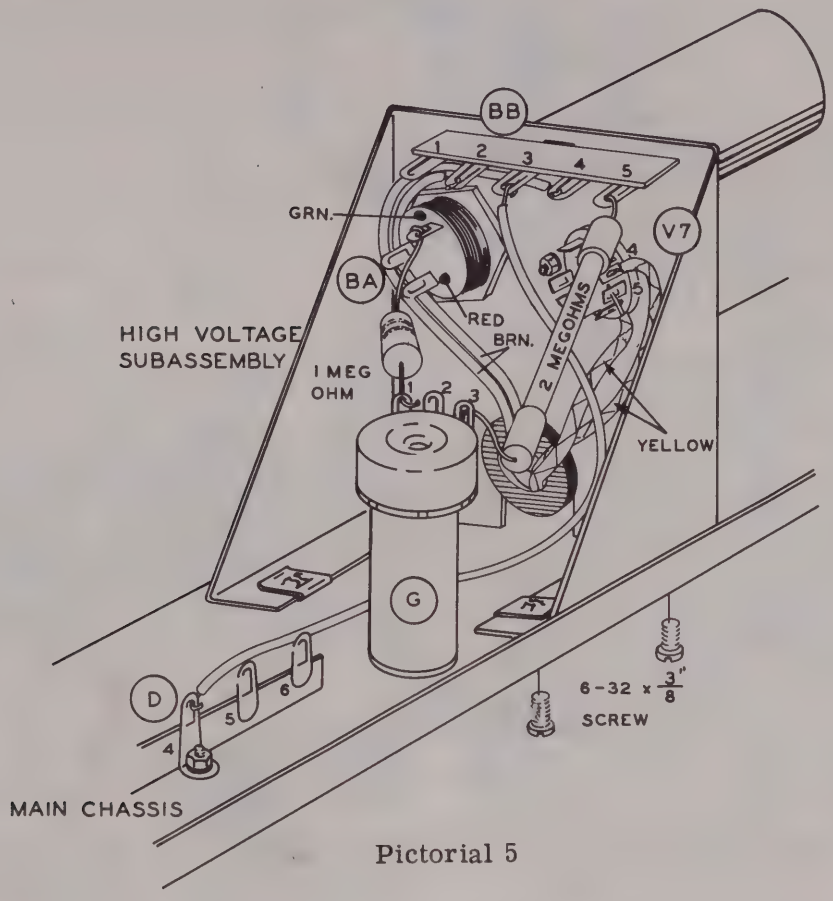
(✓) Mount the High Voltage 5-lug terminal strip at BB. Use #6 hardware.

(✓) Connect a 2-1/2" wire from the uncolored lug of filter capacitor BA (S-1) to lug 3 of terminal strip BB (NS).

(✓) Connect a 1-1/2" wire from the red lug of filter capacitor BA (NS) to lug 9 of tube socket V7 (S-1).

(✓) R41. Connect a 100 KΩ (brown-black-yellow) 1 watt resistor from the green lug of filter capacitor BA (NS) to lug 4 of terminal strip BB (NS).

(✓) R45. Connect another 100 KΩ (brown-black-yellow) 1 watt resistor between the red lug (S-2) and the green lug (NS) of filter capacitor BA.




Pictorial 5

( ) R37. Connect a 2 megohm precision resistor between lugs 1 (NS) and 5 (NS) of terminal strip BB. Position this resistor away from other lugs on terminal strip BB.

( ) Install four #6 speednuts on the subassembly as shown in Pictorial 4. Be sure the flat sides face outward.

## MOUNTING AND WIRING HIGH VOLTAGE SUBASSEMBLY

Refer to Pictorial 5 for the following steps.

( ) Mount the High Voltage Subassembly on the main chassis as shown. Use 6-32 x 3/8" screws. Be sure to position the transformer wires and rubber grommet in place. Be sure that no leads are between the subassembly and the main chassis.

( ) Connect either one of the yellow transformer leads to lug 5 of tube socket V7 (S-1).

( ) Connect the other yellow transformer lead to lug 4 of tube socket V7 (S-1).

( ) Connect one of the brown transformer leads to lug 2 of terminal strip BB (NS). Route as shown.

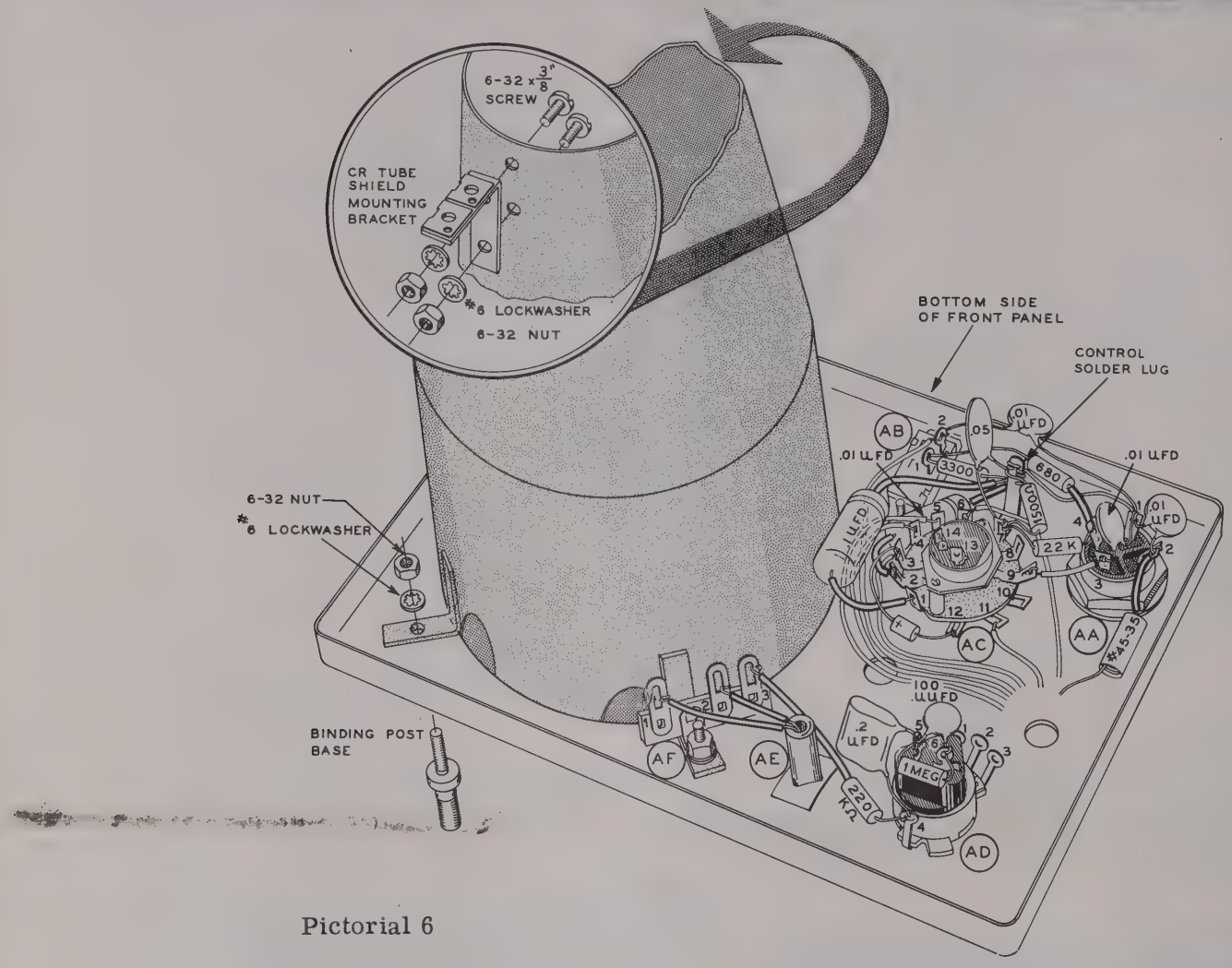
( ) Connect the other brown transformer lead to lug 4 of terminal strip BB (NS). Route as shown.

( ) Connect a 7" wire from lug 4 of terminal strip D (NS) to lug 3 of terminal strip BB (S-2).

( ) R38. Connect a 2 megohm precision resistor from lug 5 of terminal strip BB (S-2) to lug 3 of control G (S-1).

( ) R40. Connect a 1 megohm (brown-black-green) 1 watt resistor from lug 1 of control G (S-1) to the green lug of filter capacitor BA (NS).

Temporarily set the chassis assembly aside.




Pictorial 6

## FRONT PANEL SUBASSEMBLY

Refer to Pictorial 6 for the following steps.

( ) Locate the front panel and position as shown in Pictorial 6. It is a good idea to place a soft cloth over your work area to prevent scratching the front panel.

( ) Mount the connector socket at AA. Use the hardware supplied and position the socket as shown. Making sure that the slot is down, thread the large hex nut against the collar, then, with the lockwasher in place, tighten the knurled nut by hand. Now, securely tighten the hex nut against the front panel.

( ) Mount the 2-lug slide switch at AB. Be sure to position the lugs as shown. Use 6-32 x 3/8" screws to secure the switch.

( ) Locate the Selector switch (#63-239) and turn the shaft fully counterclockwise. Mount the switch at location AC with the flat side of the shaft away from the AC OFF position on the front panel. Use a control solder lug, control flat washer, and control nut. Make sure that the solder lug is placed as shown in Pictorial 6. NOTE: The large knob should be installed on the switch shaft before any wiring is done. The pointer on the knob should line up with the markings on the front panel. If the pointer does not line up, loosen the switch and rotate it to the correct position.

NOTE: A short length of tape marked with the switch lug number should be attached to each wire connected in the following six steps.

( ) Connect a 7-1/2" wire to lug 2 of switch AB (NS). Leave the other end free.

( ) Connect a 5-1/2" wire to lug 3 of switch AC (NS). Leave the other end free.

( ) Connect a 3-1/2" wire to lug 4 of switch AC (S-1). Leave the other end free.

( ) Connect a 4-1/2" wire to lug 5 of switch AC (S-1). Leave the other end free.

( ) Connect a 5" wire to lug 6 of switch AC (S-1). Leave the other end free.

( ) Connect a 3-1/2" wire to lug 11 of switch AC (S-1). Leave the other end free.

Dress the wires previously connected as shown in Pictorial 6.

( ) Connect a 1-1/4" wire from lug 9 of switch AC (S-1) to lug 3 of connector socket AA (NS).

( ) D4. Connect the positive (+) lead of the small silicon diode to lug 3 of switch AC (S-2). Connect the other lead of the diode to lug 12 of AC (S-1).

( ) C12. Connect a .01 µfd tubular capacitor from lug 2 of switch AC (S-1) to the control solder lug on switch AC (NS). Use sleeving on both leads.

( ) C13. Connect a .1 µfd tubular capacitor from lug 1 of switch AC (S-1) to the solder lug on switch AC (NS). Use sleeving on both leads.

( ) R22. Connect a 22 KΩ (red-red-orange) resistor from lug 7 of switch AC (NS) to lug 4 of connector socket AA (NS).

( ) R25. Connect a 1500 Ω (brown-green-red) resistor from lug 7 of switch AC (NS) to the control solder lug on AC (NS).

( ) R24. Connect a 3300 (orange-orange-red) resistor from the control solder lug on switch AC (NS) to lug 1 on switch AB (NS).

( ) C15. Connect a .05 µfd disc ceramic capacitor from the control solder lug on switch AC (NS) to lug 7 on switch AC (S-3).

( ) L1. Cut one lead of the #45-35 coil to 3/4". Connect this lead to lug 2 of connector socket AA (NS). Use sleeving. Leave the other end free.

( ) R23. Connect a 680 Ω (blue-gray-brown) resistor from lug 4 of connector socket AA (S-2) to lug 1 of switch AB (S-2). Use sleeving on the lead to lug 4 of AA.

( ) C1. Connect one lead of a .01 µfd disc ceramic capacitor to lug 2 of connector socket AA (S-2). Place the other lead of this capacitor through lug 1 of connector AA (NS) to the control solder lug on switch AC (S-6).

( ) C14. Connect a .01 µfd disc ceramic capacitor between lugs 1 (NS) and 3 (S-2) of connector socket AA.

( ) C4. Connect another .01 µfd disc ceramic capacitor from lug 1 of connector socket AA (S-4) to lug 2 of switch AB (S-2).

( ) Mount the red neon pilot lamp at location AE. Use a large push-on speednut.

( ) R32. Mount the 20 KΩ VERTical POSition control (#19-55) AD with the single lug toward the top of the front panel as shown. Use a control lockwasher, control flat washer, and control nut.

( ) Mount the CR tube shield and 3-lug terminal strip AF. No lockwasher is used under the mounting foot. Be sure that the side of the shield with the two small holes is facing the bottom side of the front panel. Center the binding post bases with the grid screen plate before tightening the nuts. Shift the shield as far as possible to the side, away from the control and switch. Use the binding post bases, #6 lockwashers, and 6-32 nuts.

( ) Mount the CR tube shield mounting bracket as shown. Use #6 hardware.

( ) Install #6 speednuts on the CR tube shield mounting bracket. The flat side should be facing toward the rear of the assembly.

( ) R27. Connect a 1 megohm (brown-black-green) resistor between lugs 5 (NS) and 6 (NS) of control AD.

( ) C17. Connect a 100 µµf disc ceramic capacitor between lugs 5 (NS) and 6 (NS) of control AD.

( ) R26. Connect a 220 KΩ (red-red-yellow) resistor from lug 4 of control AD (NS) to lug 3 of terminal strip AF (NS). Use sleeving on the lead going to AF.

( ) C16. Connect a .2 µfd mylar capacitor between lugs 4 (S-2) and 5 (S-3) of control AD.

( ) Connect either one of the leads coming from pilot light AE to lug 1 of terminal strip AF (NS). Use sleeving.

( ) Connect the other lead of pilot light AE to lug 2 of terminal strip AF (NS). Use sleeving.

Refer to Pictorial 7 (fold-out Page 19) for the following steps.

( ) Place the main chassis in position on the front panel and place the wires coming from switches AB and AC through grommet A.

( ) R12. Secure the front panel to the main chassis with the LEFT EDGE control AH (#10-32). Use a control solder lug, control flat washer, and control nut. Make sure that the solder lug is positioned as shown.

( ) R36. Mount the 7.5 megohm RIGHT EDGE (#10-94) control at AG. Use a control lockwasher, control flat washer, and control nut.

( ) Using #6 hardware, mount the CR tube support mounting bracket on the side flange of the main chassis.

( ) Secure the CR tube support mounting bracket to the CR tube shield mounting bracket. Use two 6-32 x 3/8" screws.

( ) Connect the wire coming from lug 2 of slide switch AB to lug 5 of terminal strip C (S-2).

( ) Connect the wire coming from lug 3 of switch AC to lug 2 of tube socket V3 (S-2).

3AC TO 2V3

( ) Connect the wire coming from lug 4 of switch AC to lug 1 of control AH (NS).

( ) Connect the wire coming from lug 5 of switch AC to lug 7 of tube socket V3 (S-1).

5AC TO 7V3

( ) Connect the wire coming from lug 6 of switch AC to lug 2 of control AH (S-1).

( ) Connect the wire coming from lug 11 of switch AC to lug 8 of tube socket V3 (S-2).

## HARNESS WIRING ON MAIN CHASSIS

( ) Locate the wiring harness and position it on the main chassis so that the CR tube socket is to your right as shown in Pictorial 7. Place the long portion of the harness that contains the gray shielded cable through grommet M.

( ) Place a plastic cable clamp around the harness between breakout points A and B. Secure the clamp to the main chassis at the location shown in Pictorial 7. Use #6 hardware.

( ) Remove the #6 hardware holding the plastic cable clamp and one end of terminal strip K. Place the harness through the clamp near grommet M. Secure the clamp and terminal strip K to the main chassis with #6 hardware.

In the following steps the wiring harness will be connected.

POINT A

( ) Brown wire to lug 3 of control AG (NS).

( ) Gray wire to lug 3 of control AD (S-1).

( ) Blue wire to lug 2 of control AD (S-1).

( ) Place the orange wire through grommet A to be connected later.

POINT B

( ) White wire to lug 6 of tube socket V4 (S-2).

POINT C

( ) Black wire to lug 1 of tube socket V4 (S-2).

( ) Yellow wire to lug 6 of tube socket V5 (S-2).

( ) Blue wire to lug 7 of tube socket V5 (S-2).

POINT D

( ) Green wire to lug 9 of tube socket V5 (S-3).

( ) Orange wire to lug 1 of tube socket V5 (S-2).

( ) Gray shielded cable to lug 6 of terminal strip D (NS).

( ) Gray wire to lug 5 of terminal strip D (S-2).

POINT E

Extending from point E are heavy wires. The wires will be referred to with the letters HV.

( ) HV black wire to the green dot lug of electrolytic capacitor BA (S-4).

( ) HV orange wire to lug 2 of terminal strip BB (S-2).

( ) HV brown wire to lug 4 of terminal strip BB (S-3).

( ) HV red wire to lug 2 of control G (S-1).

( ) Brown wire to lug 1 of terminal strip BB (S-2).

( ) Red wire to lug 2 of control F (S-1).

This completes the harness wiring at this time.

( ) Connect a 5-1/2" wire from lug 1 of terminal strip AF (S-2) to lug 3 of control AG (S-2).

( ) Connect a 4-1/2" wire from lug 2 of terminal strip AF (S-2) to lug 3 of tube socket V3 (S-2).

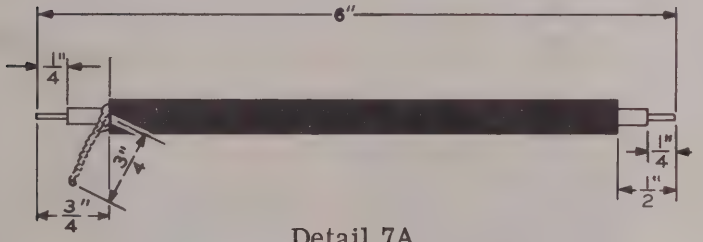
( ) Connect a 4" wire from lug 2 of control AG (S-1) to lug 3 of terminal strip C (S-2).

( ) Connect a 6" wire to lug 7 of the tube socket V1 (S-2). Place the free end through grommet B to be connected later.

( ) R11. Connect a 47 KΩ (yellow-violet-orange) resistor from lug 1 of control AH (S-2) to lug 1 of terminal strip C (S-2).

( ) R35. Wrap one lead of a 27 KΩ (red-violet-orange) resistor around the control solder lug on control AH (NS) and then connect it to lug 3 of control AH (S-1). Connect the other lead of this resistor to lug 1 of control AD (S-1).

( ) Cut two 6" lengths of single-wire shielded cable and prepare them as shown in Detail 7A.

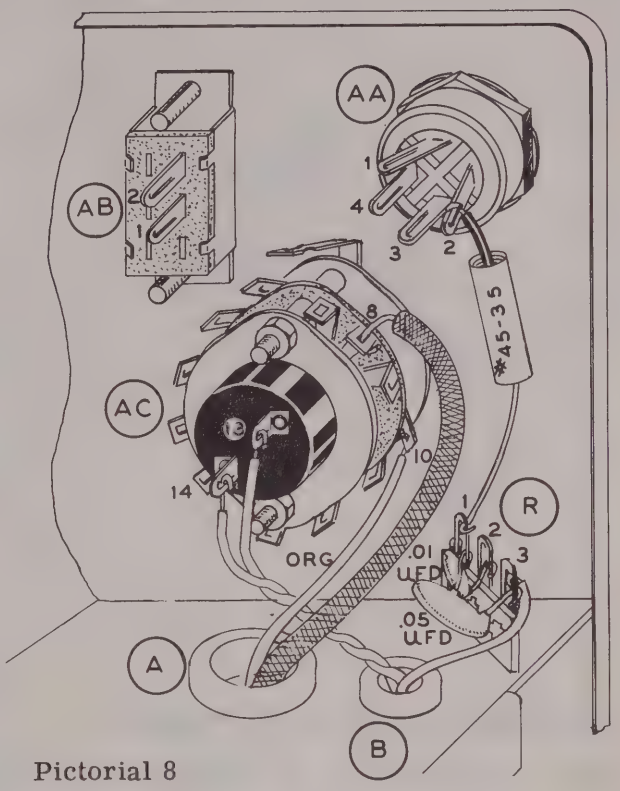



Detail 7A

( ) At one end, connect the shield pigtail of one of these cables to the control solder lug on control AH (S-3). Connect the inner lead to lug 3 of terminal strip AF (S-2). Place the other end of this cable through grommet A to be connected later.

( ) At one end of the remaining prepared cable connect the shield pigtail to lug 4 of terminal strip D (S-5). Connect the inner lead to lug 6 of D (S-4).

( ) At the other end connect the inner lead to lug 6 of control AD (S-3). The shield is not connected at this end.




Pictorial 8

## FINAL FRONT PANEL WIRING

Refer to Pictorial 8 for the following steps.

( ) Connect the orange harness wire, coming through grommet A, to lug 10 of switch AC (S-1).

( ) Connect the inner wire of the shielded cable, coming through grommet A, to lug 8 of switch AC (S-1). The shield is not used.

( ) Connect either one of the twisted wires, coming through grommet B, to lug 14 on switch AC (S-1).

( ) Connect the other twisted wire to lug 13 on switch AC (S-1).

( ) Connect the remaining wire, coming through grommet B, to lug 3 of terminal strip R (NS).

( ) Connect the free end of the (#45-35) coil to lug 1 of terminal strip R (NS).

( ) C2. Connect a .01 µfd disc ceramic capacitor between lugs 1 (NS) and 2 (S-1) of terminal strip R.

( ) C3. Connect a .05 µfd disc ceramic capacitor between lugs 1 (S-3) and 3 (S-2) of terminal strip R.

Refer to Pictorial 7 (fold-out Page 19) for the following steps.

( ) Place the main chassis in position on the front panel and place the wires coming from switches AB and AC through grommet A.

( ) R12. Secure the front panel to the main chassis with the LEFT EDGE control AH (#10-32). Use a control solder lug, control flat washer, and control nut. Make sure that the solder lug is positioned as shown.

( ) R36. Mount the 7.5 megohm RIGHT EDGE (#10-94) control at AG. Use a control lockwasher, control flat washer, and control nut.

( ) Using #6 hardware, mount the CR tube support mounting bracket on the side flange of the main chassis.

( ) Secure the CR tube support mounting bracket to the CR tube shield mounting bracket. Use two 6-32 x 3/8" screws.

( ) Connect the wire coming from lug 2 of slide switch AB to lug 5 of terminal strip C (S-2).

( ) Connect the wire coming from lug 3 of switch AC to lug 2 of tube socket V3 (S-2).

( ) Connect the wire coming from lug 4 of switch AC to lug 1 of control AH (NS).

( ) Connect the wire coming from lug 5 of switch AC to lug 7 of tube socket V3 (S-1).

( ) Connect the wire coming from lug 6 of switch AC to lug 2 of control AH (S-1).

( ) Connect the wire coming from lug 11 of switch AC to lug 8 of tube socket V3 (S-2).

## HARNESS WIRING ON MAIN CHASSIS

( ) Locate the wiring harness and position it on the main chassis so that the CR tube socket is to your right as shown in Pictorial 7. Place the long portion of the harness that contains the gray shielded cable through grommet M.

( ) Place a plastic cable clamp around the harness between breakout points A and B. Secure the clamp to the main chassis at the location shown in Pictorial 7. Use #6 hardware.

( ) Remove the #6 hardware holding the plastic cable clamp and one end of terminal strip K. Place the harness through the clamp near grommet M. Secure the clamp and terminal strip K to the main chassis with #6 hardware.

In the following steps the wiring harness will be connected.

POINT A

( ) Brown wire to lug 3 of control AG (NS).

( ) Gray wire to lug 3 of control AD (S-1).

( ) Blue wire to lug 2 of control AD (S-1).

( ) Place the orange wire through grommet A to be connected later.

POINT B

( ) White wire to lug 6 of tube socket V4 (S-2).

POINT C

( ) Black wire to lug 1 of tube socket V4 (S-2).

( ) Yellow wire to lug 6 of tube socket V5 (S-2).

( ) Blue wire to lug 7 of tube socket V5 (S-2).

POINT D

( ) Green wire to lug 9 of tube socket V5 (S-3).

( ) Orange wire to lug 1 of tube socket V5 (S-2).

( ) Gray shielded cable to lug 6 of terminal strip D (NS).

( ) Gray wire to lug 5 of terminal strip D (S-2).

POINT E

Extending from point E are heavy wires. The wires will be referred to with the letters HV.

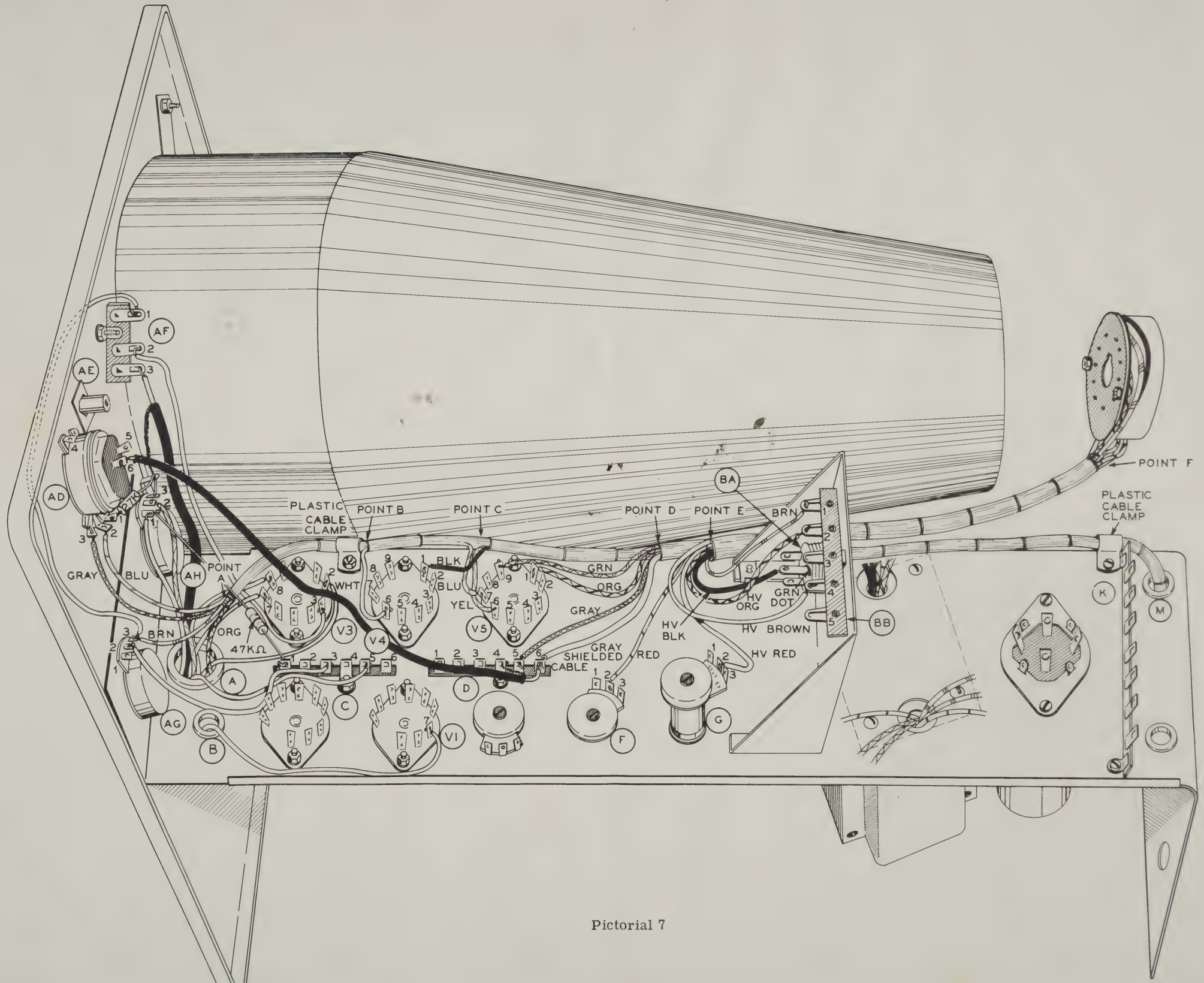
( ) HV black wire to the green dot lug of electrolytic capacitor BA (S-4).

( ) HV orange wire to lug 2 of terminal strip BB (S-2).

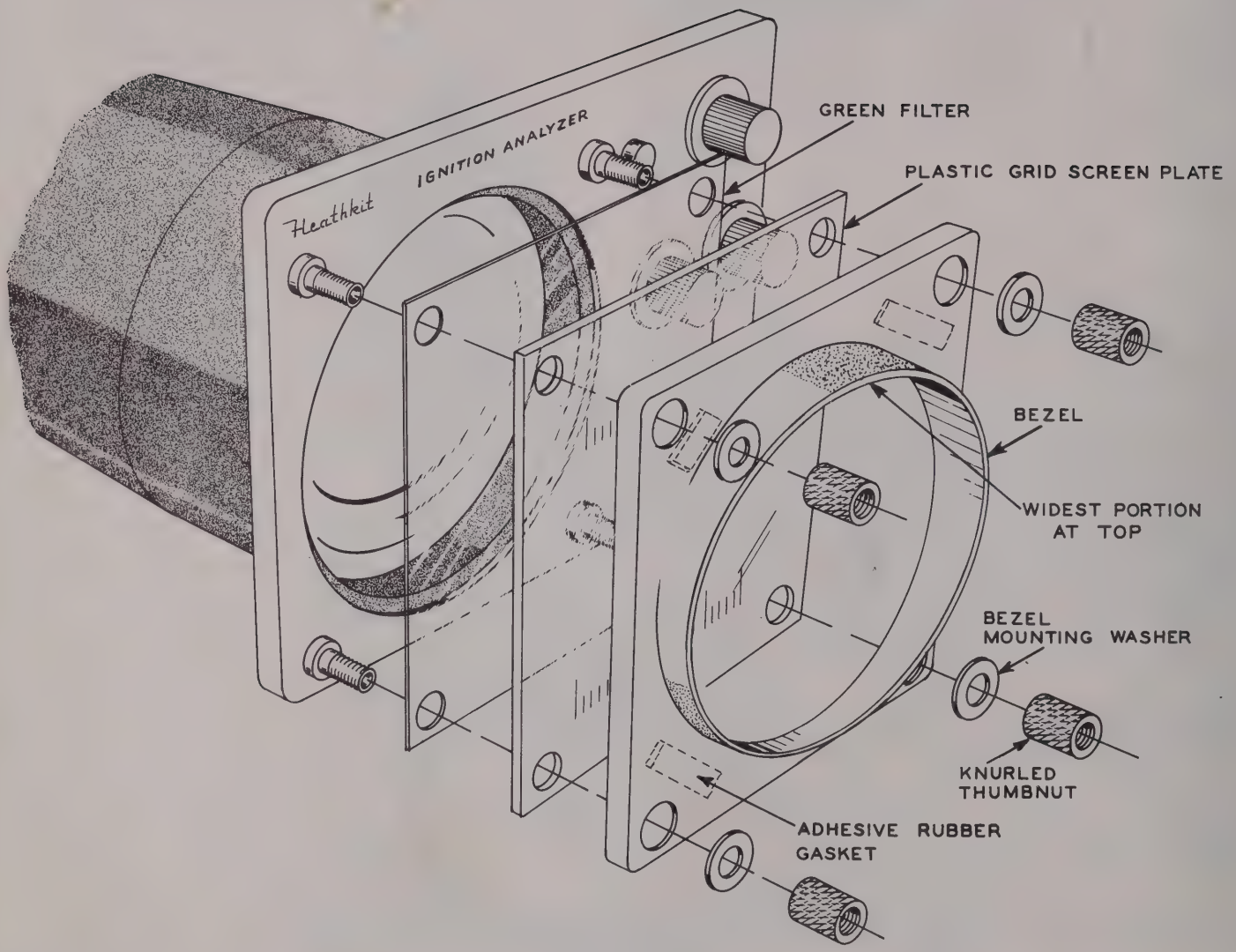
( ) HV brown wire to lug 4 of terminal strip BB (S-3).

( ) HV red wire to lug 2 of control G (S-1).

( ) Brown wire to lug 1 of terminal strip BB (S-2).

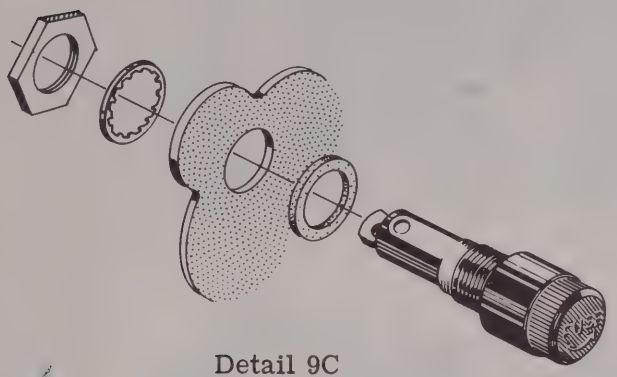

AF
AE
AD
AH
AG
BA
BB
AK
AM
A
B
C
D
F
G
V1
V3
V4
V5
1
2
3
4
5
6
PLASTIC CABLE CLAMP
POINT A
POINT B
POINT C
POINT D
POINT E
POINT F
PLASTIC CABLE CLAMP
GRAY
BLU
BRN
ORG
47KΩ
WHT
BLK
BLU
YEL
GRN
ORG
GRAY
HV BLK
HV ORG
GRN DOT
HV BROWN
HV RED
GRAY SHIELDED CABLE
RED

Pictorial 7




Pictorial 11

( ) Connect a 5-1/2" wire to lug 2 of fuse holder P (S-1). Place the wire through grommet M to be connected later.



Detail 9C

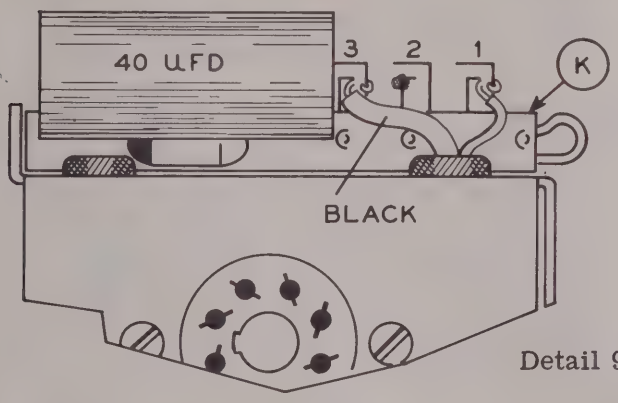
( ) Connect the white line cord wire to lug 1 of fuse holder P (S-1).

( ) Connect the green line cord wire to the solder lug nearest lug 1 of accessory power socket N (S-2).

( ) Place the black line cord wire through grommet M and, referring to Detail 9D, connect the black line cord wire to lug 3 of terminal strip K (S-2).

( ) Connect the remaining wire coming through grommet M to lug 1 of terminal strip K (S-2).

This completes the wiring of the instrument itself.




Detail 9D

Refer to Pictorial 10 (fold-out Page 20) for the following steps.

( ) Install the 1/2 ampere fuse in fuse holder P.

( ) Place a #6 speednut on each side of the rear chassis flange. Make sure that the flat side is facing outward.

( ) Install three #6 speednuts on the CR tube support mounting bracket. Be sure the flat sides are facing as shown in Pictorial 10.

CAUTION: Carefully open the carton containing the 5UP1 cathode ray tube. Handle the tube with reasonable caution, since it has been highly evacuated. Should the envelope be broken, the resulting implosion could spray the area with shattered glass with possibly serious consequences. Avoid handling the tube while wearing diamond rings which might scratch the glass. Do not strike the envelope with tools and do not subject it to impact or shock.

( ) Insert the 5UP1 CR tube from the front panel into the CR tube shield until the center of the CR tube face is approximately 1/4" inside of the front panel. Note the position of the keyway on the tube base.

( ) Locate one of the CR tube mounting brackets and fit the rubber cushion strip over the mounting bracket.

( ) Place the bracket under the neck of the CR tube so that it is directly over the two speednuts.

( ) Fit the rubber cushion strip into the remaining mounting bracket and temporarily secure the two brackets with 6-32 x 1" screws. Use care in tightening since it is possible to damage the CR tube.

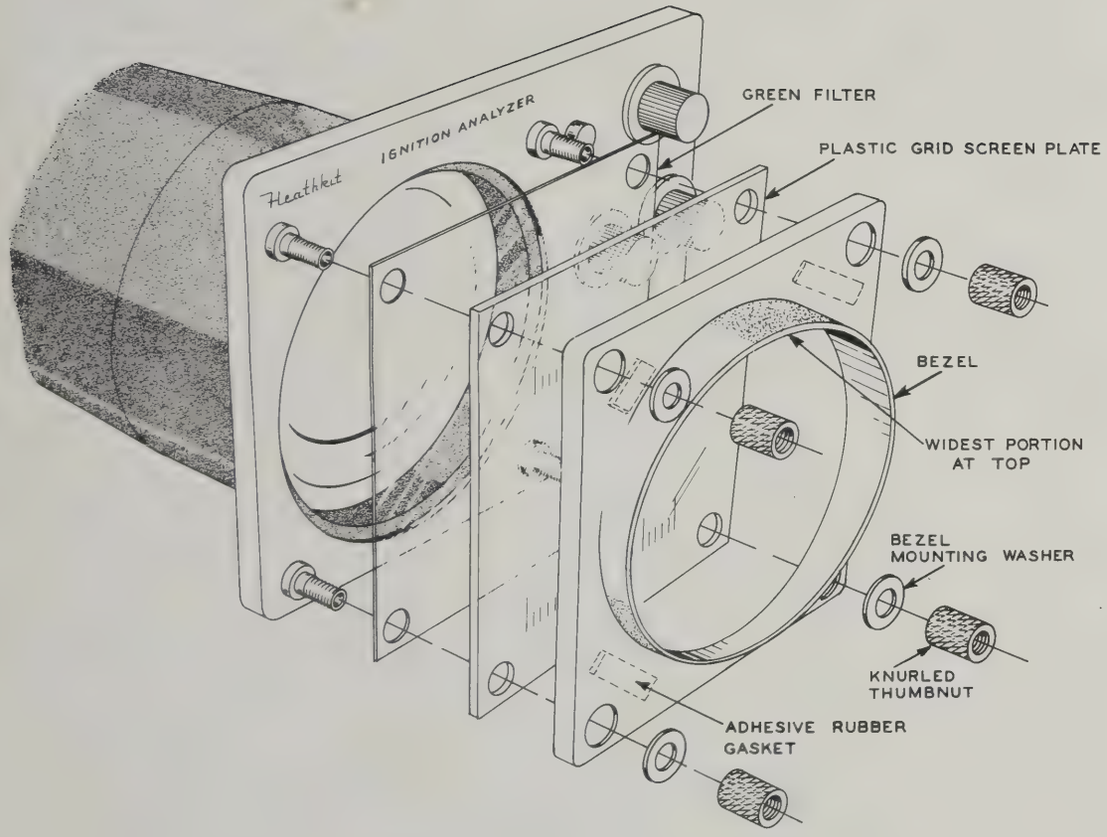
( ) Place the CR tube socket over the end of the tube. Notice the keyway in the socket and the key on the tube base.

Refer to Pictorial 11 (fold-out Page 20) for the following steps.

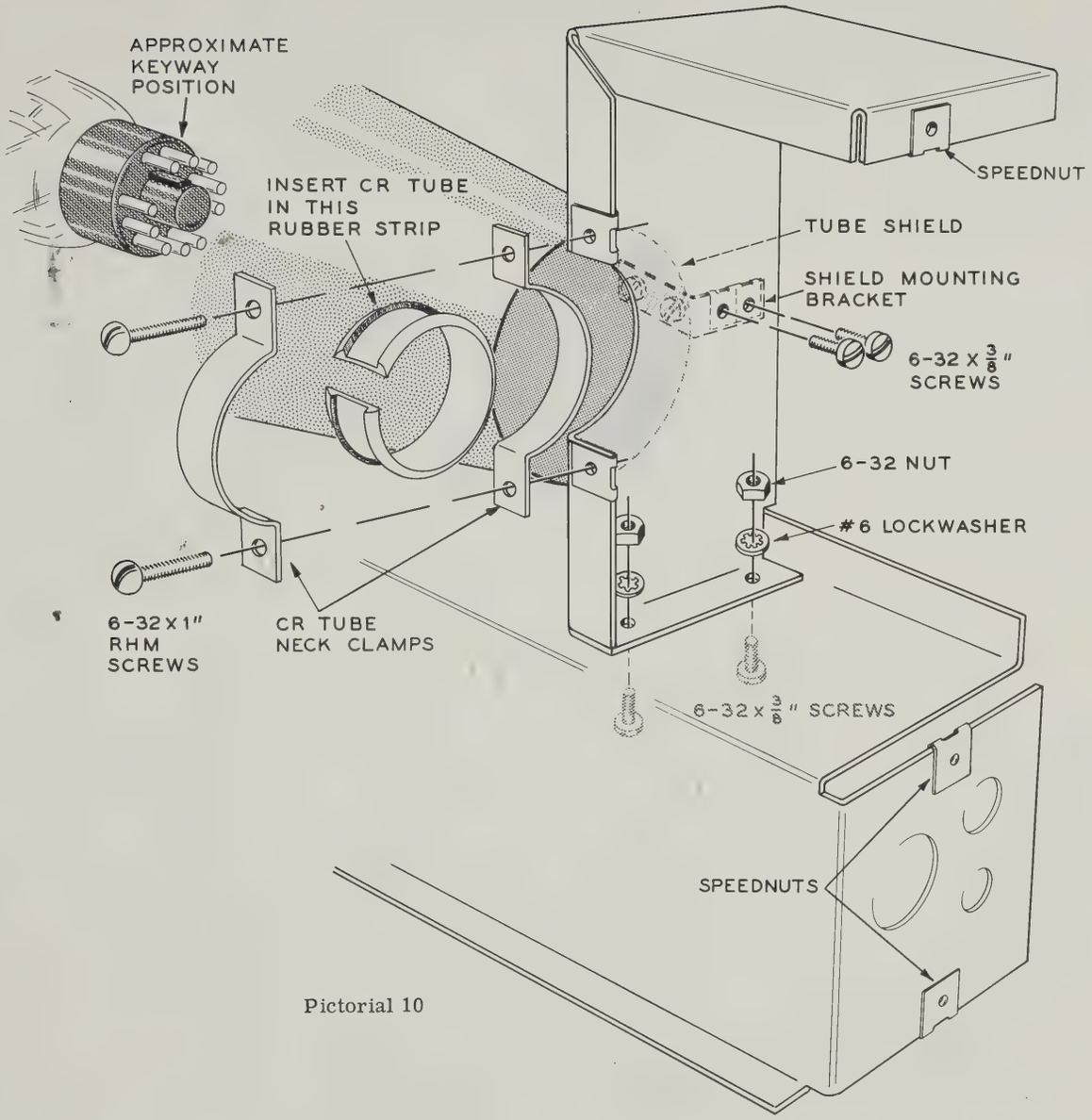
( ) Cut the adhesive rubber gasket into four 1/2" lengths. Remove the backing and stick one on each inside corner of the bezel. See Pictorial 11.

( ) Install the green plastic filter, plastic grid screen plate, and bezel. Secure them with the bezel mounting washer and knurled thumbnut. Note that the wider portion of bezel rim is toward the top of the panel.

( ) Rotate all controls on the front panel to their maximum counterclockwise position. Mount the knobs on the controls with the white arrow indicating the beginning of their rotation. Also mount the small knobs on the two chassis controls, FOCUS and ASTIGMATISM.

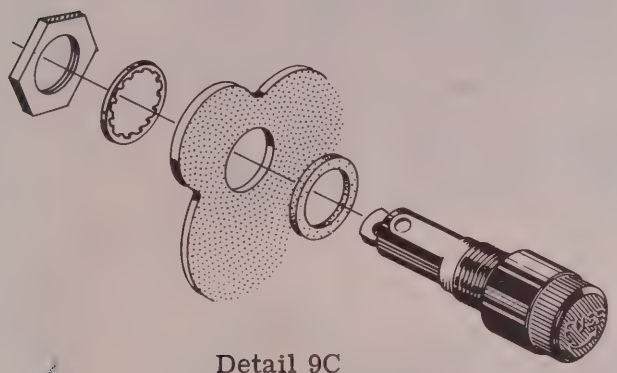



Pictorial 11




Pictorial 10

( ) Connect a 5-1/2" wire to lug 2 of fuse holder P (S-1). Place the wire through grommet M to be connected later.



Detail 9C

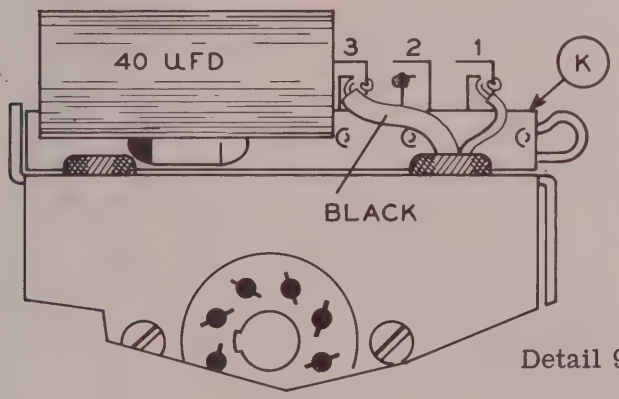
( ) Connect the white line cord wire to lug 1 of fuse holder P (S-1).

( ) Connect the green line cord wire to the solder lug nearest lug 1 of accessory power socket N (S-2).

( ) Place the black line cord wire through grommet M and, referring to Detail 9D, connect the black line cord wire to lug 3 of terminal strip K (S-2).

( ) Connect the remaining wire coming through grommet M to lug 1 of terminal strip K (S-2).

This completes the wiring of the instrument itself.




Detail 9D

Refer to Pictorial 10 (fold-out Page 20) for the following steps.

( ) Install the 1/2 ampere fuse in fuse holder P.

( ) Place a #6 speednut on each side of the rear chassis flange. Make sure that the flat side is facing outward.

( ) Install three #6 speednuts on the CR tube support mounting bracket. Be sure the flat sides are facing as shown in Pictorial 10.

CAUTION: Carefully open the carton containing the 5UP1 cathode ray tube. Handle the tube with reasonable caution, since it has been highly evacuated. Should the envelope be broken, the resulting implosion could spray the area with shattered glass with possibly serious consequences. Avoid handling the tube while wearing diamond rings which might scratch the glass. Do not strike the envelope with tools and do not subject it to impact or shock.

( ) Insert the 5UP1 CR tube from the front panel into the CR tube shield until the center of the CR tube face is approximately 1/4" inside of the front panel. Note the position of the keyway on the tube base.

( ) Locate one of the CR tube mounting brackets and fit the rubber cushion strip over the mounting bracket.

( ) Place the bracket under the neck of the CR tube so that it is directly over the two speednuts.

( ) Fit the rubber cushion strip into the remaining mounting bracket and temporarily secure the two brackets with 6-32 x 1" screws. Use care in tightening since it is possible to damage the CR tube.

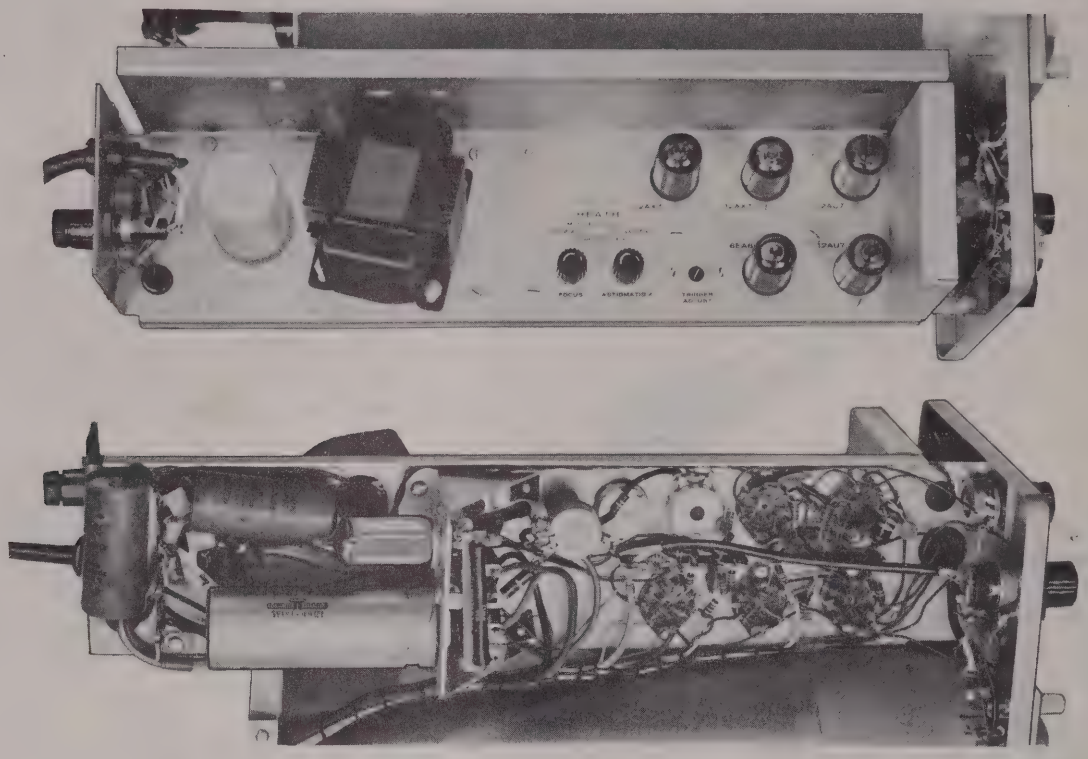
( ) Place the CR tube socket over the end of the tube. Notice the keyway in the socket and the key on the tube base.

Refer to Pictorial 11 (fold-out Page 20) for the following steps.

( ) Cut the adhesive rubber gasket into four 1/2" lengths. Remove the backing and stick one on each inside corner of the bezel. See Pictorial 11.

( ) Install the green plastic filter, plastic grid screen plate, and bezel. Secure them with the bezel mounting washer and knurled thumbnut. Note that the wider portion of bezel rim is toward the top of the panel.

( ) Rotate all controls on the front panel to their maximum counterclockwise position. Mount the knobs on the controls with the white arrow indicating the beginning of their rotation. Also mount the small knobs on the two chassis controls, FOCUS and ASTIGMATISM.



Pictorial 12

## INITIAL TEST AND ADJUSTMENT

( ) Compare the wiring to the Pictorials and to the photographs on the rear of the fold-out Schematic Diagram. Make sure that there are no short circuits in the wiring caused by wire clippings or stray pieces of solder. Examine all connections to make sure they are soldered.

IMPORTANT WARNING: TUBES CAN BE DAMAGED WHEN INSTALLING THEM IN THEIR SOCKETS. THEREFORE, USE EXTREME CARE WHEN INSTALLING TUBES AS WE DO NOT GUARANTEE OR REPLACE TUBES BROKEN DURING HANDLING OR INSTALLATION.

( ) Referring to Pictorial 12, install tubes V1 (6EA8), V2 (12AU7), V3 (12AU7), V4 (12AX7), V5 (12AX7), and V7 (IV2) in the appropriate tube sockets.

( ) Temporarily connect a short jumper wire between lugs 3 and 5 of tube socket V1. Refer to Pictorial 13.

( ) Set the controls as follows:

VERT. EXPAND - Normal
VERT. POSITION - Halfway
RIGHT EDGE - Full clockwise
LEFT EDGE - Full clockwise
PARADE/SUPERIMPOSED - SUPERIMPOSED
Function Selector - AC OFF

Chassis Controls:

FOCUS - Halfway
ASTIGMATISM - Halfway
TRIGGER ADJUST - Full counterclockwise

NOTE: Care should be taken when making tests and adjustments when the cabinet is not in place. Always turn the unit OFF when making the connection indicated in the following steps.

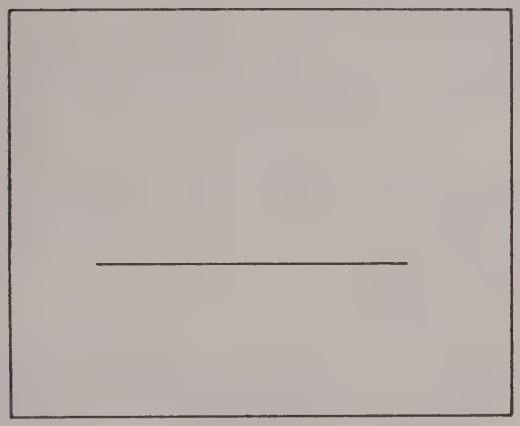
( ) Insert the line cord plug into a 117 volt 50/60 cycle AC receptacle. NOTE: Use the 3-pin plug adapter if the proper outlet is not available.

( ) Rotate the function selector switch to SECONDARY NORMAL and notice the following:

A. The neon pilot lamp and the tube filaments should light. If after several seconds the neon pilot lamp does not light, turn the unit off and refer to the IN CASE OF DIFFICULTY section.

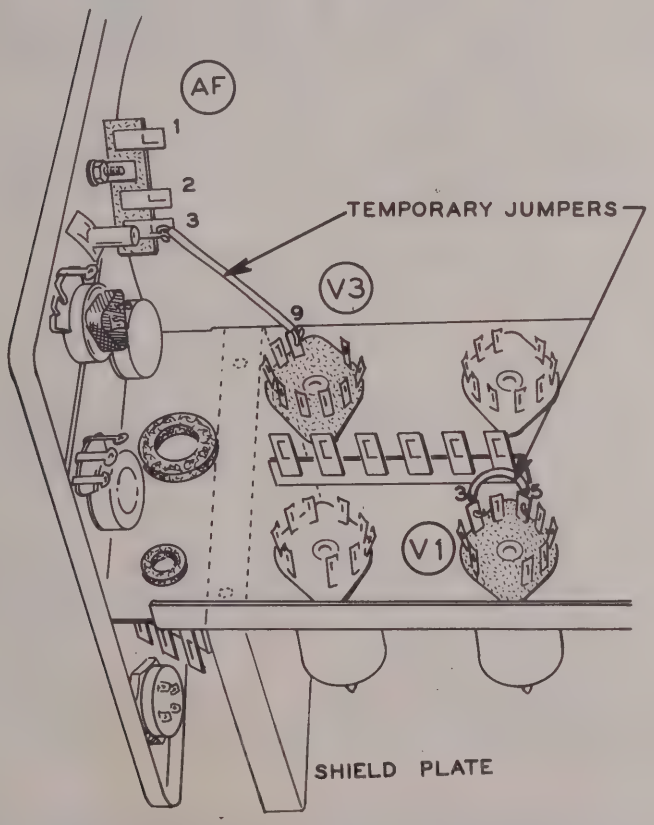
B. All tube filaments should be glowing except in the IV2. The pilot lamp indicates that the IV2 is operating properly.

( ) Slowly turn the LEFT EDGE control counterclockwise until the trace appears, as a straight line near the center of the screen. See Detail 13A.



Detail 13A

( ) If the trace appears to be jittery, turn the TRIGGER ADJUST control clockwise until a steady trace appears.




Pictorial 13

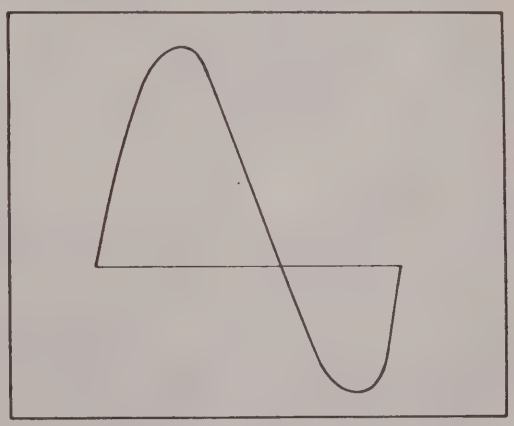
( ) Adjust the VERTical POSition control until the trace is located in the center of the screen.

( ) Alternately adjust the FOCUS and ASTIGMATISM controls for the clearest and sharpest trace.

( ) If the trace is not parallel to the grid screen plate horizontal markings, loosen the CR tube mounting brackets and rotate the CR tube until the trace is parallel to these markings. The power should be off while performing this step.

( ) Turn the analyzer off and temporarily connect an additional jumper wire between lug 9 of tube socket V3 and lug 3 of terminal strip AF. See Pictorial 13.

( ) Place the Function Selector switch back to SECONDARY NORMAL and notice that there is now a vertical pattern present. Center this pattern with the LEFT and RIGHT EDGE controls if necessary. The trace should resemble a 60 cycle sine wave. If the sine wave is not present, refer to the IN CASE OF DIFFICULTY section. See Detail 13B.

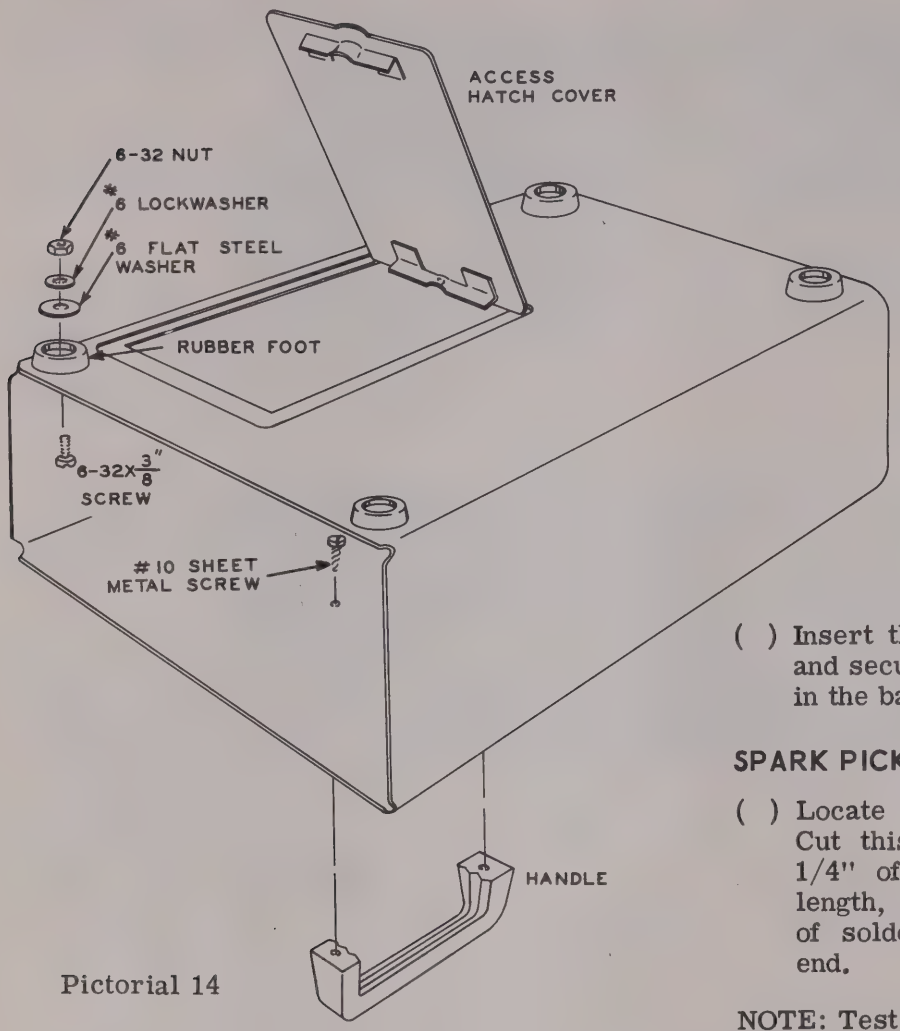


Detail 13B

( ) Pull out on the VERTical POSition control. The sine wave should expand so that the peaks extend off the screen.

( ) Readjust the FOCUS and ASTIGMATISM controls for the clearest and sharpest trace.

( ) If the analyzer operates as described above, unplug the line cord and remove both temporary jumpers. Now proceed with FINAL ASSEMBLY.




Pictorial 14

## FINAL ASSEMBLY

( ) Locate the shield plate and install three #6 speednuts with flat sides out.

( ) Referring to Pictorial 13, mount the shield plate on the tube side of the chassis, between the tubes and the front panel. Use 6-32 x 3/8" screws. Be sure no shorts exist. Position this plate as far forward as possible on the chassis.

Refer to Pictorial 14 for the following steps.

( ) Mount a rubber foot in one corner of the cabinet. Use a 6-32 x 3/8" screw, #6 flat steel washer, #6 lockwasher and 6-32 nut.

( ) Similarly, mount a rubber foot in each of the remaining corners of the cabinet.

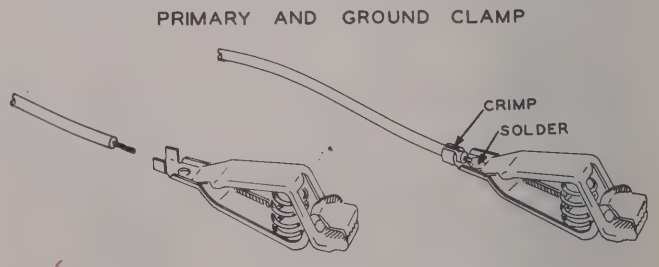
( ) Mount the handle on the cabinet using the large self-tapping screws.

( ) Insert the assembled unit into the cabinet and secure it with three 6-32 x 3/8" screws in the back panel.

## SPARK PICKUP CLAMP ASSEMBLY

( ) Locate the length of red test lead wire. Cut this length of test lead in half. Strip 1/4" of insulation from each end of one length, and "tin" (apply a small amount of solder to the exposed bare wire) each end.

NOTE: Test clips may be supplied with screws. If so, remove them as they will not be used.




Detail 15A

( ) Referring to Detail 15A, place a test clip on one end of the prepared wire. Crimp the tabs over the test lead and solder the clip to the lead.

( ) Place a red test clip insulator over the wire and over the test clip.

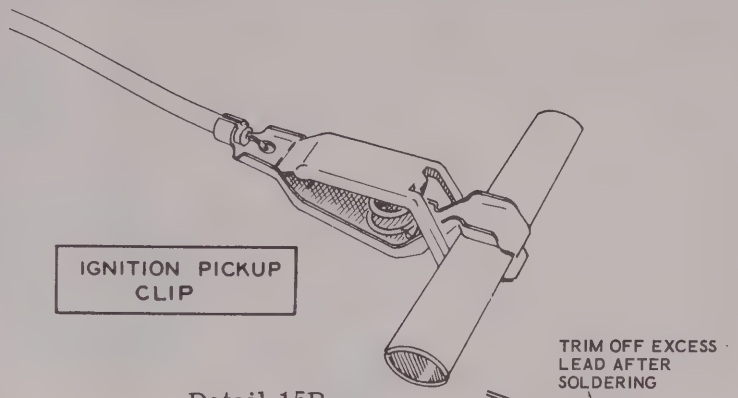
( ) Similarly, prepare a black test lead and test clip.

( ) Remove 1/4" of insulation from the remaining length of red test lead and tin the exposed ends.

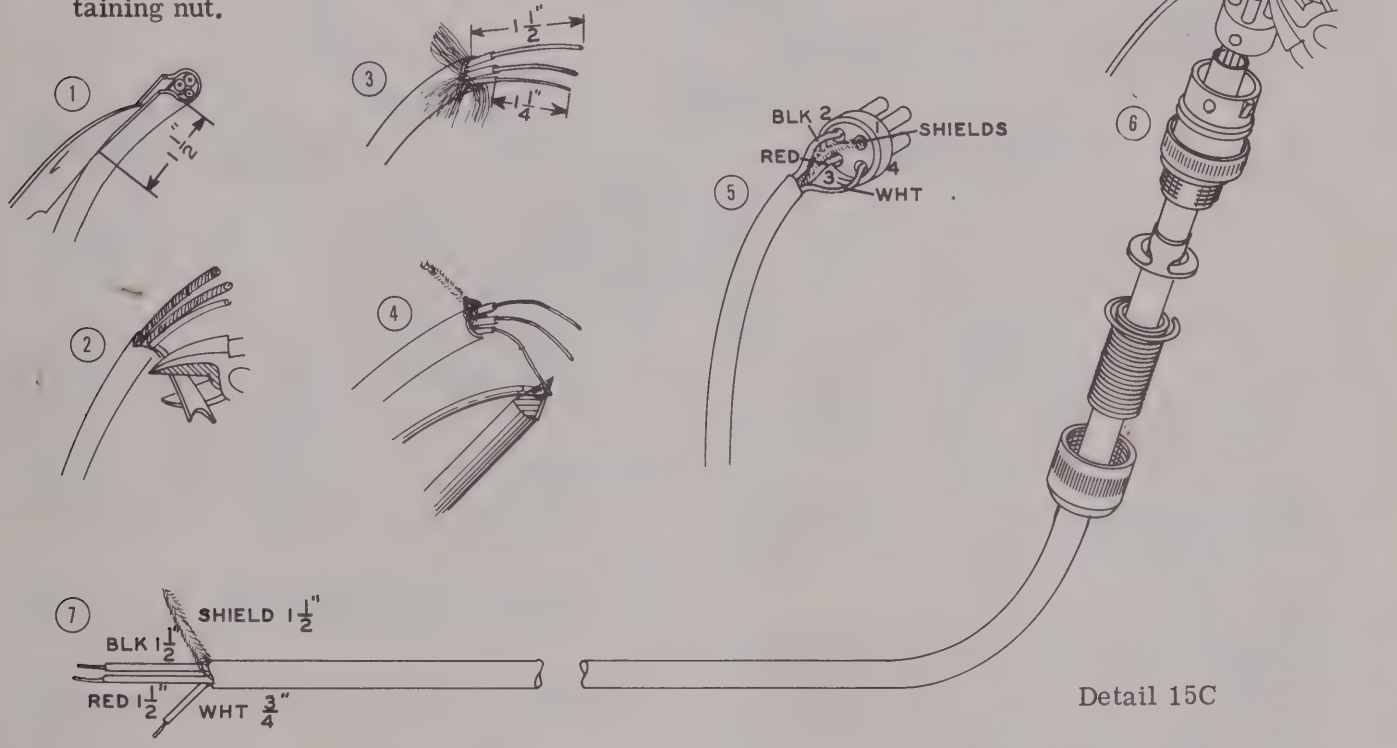
( ) Attach the ignition pickup clip and red test clip insulator in the same manner as described previously. See Detail 15B.

( ) Referring to Detail 15C, prepare the ends of the 3-conductor cable. Use care when removing the insulation from the inner wire of the small shielded cables.

( ) Disassemble the cable connector by removing the small setscrew and spring retaining nut.




Detail 15B




Detail 15C

( ) Wrap 10 strands of each shield pigtail together and clip remaining strands. Insert the twisted pigtail into pin 1 of the cable connector (S-1).

( ) Place the black wire into pin 2 of the cable connector (S-1).

( ) Place the red inner wire into pin 3 of the cable connector (S-1).

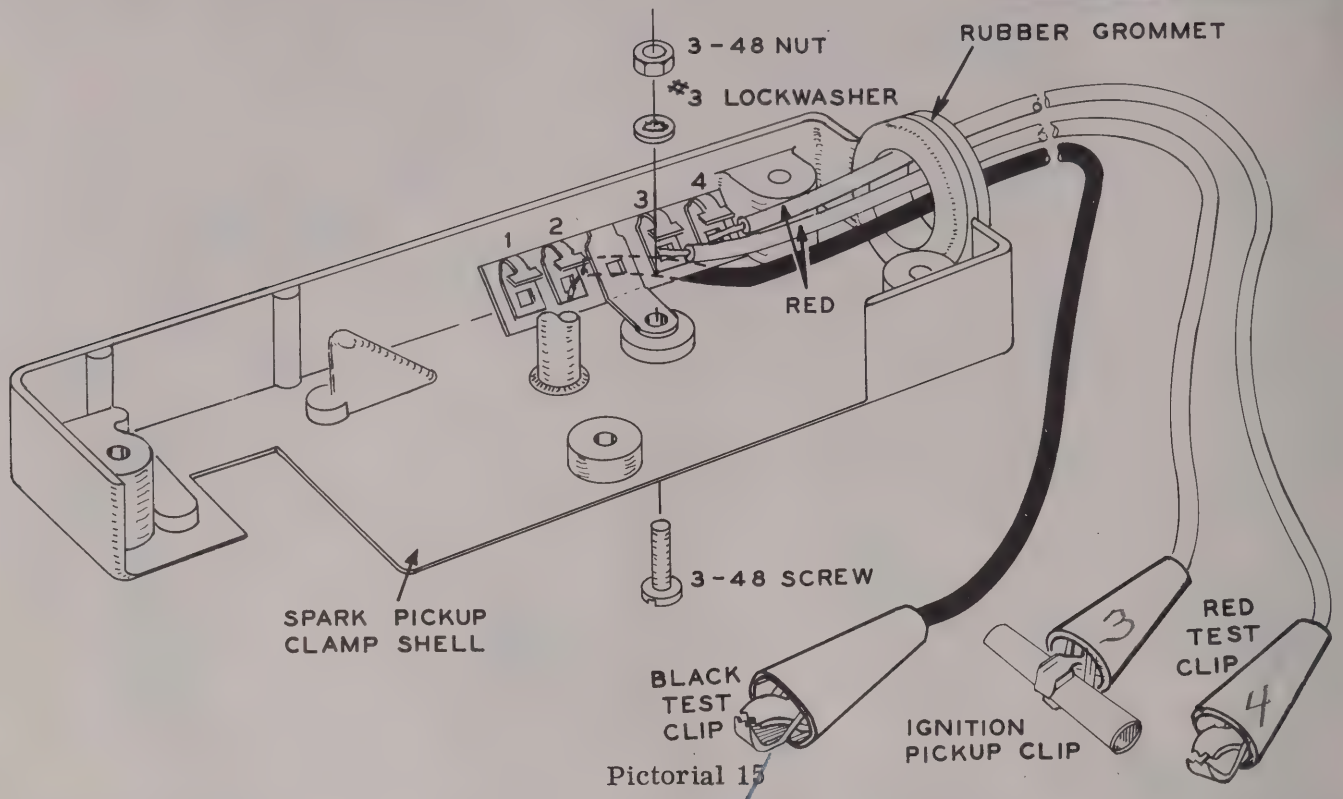
( ) Place the stripped end of the white wire into pin 4 of the cable connector (S-1).

( ) Replace the cable connector base into the connector and secure it with the small screw.

( ) Place the metal strain relief washer over the cable and bend the tabs until they touch the cable.

( ) Now place the spring retaining nut and spring over the cable and strain relief. Firmly tighten the spring retaining nut over the connector shell.

( ) Locate the miniature 5-lug terminal strip. Using diagonal cutters, remove the top lug portion of the mounting foot.




Pictorial 15

Refer to Pictorial 15 for the following steps.

( ) Mount the 5-lug miniature terminal strip in the Spark Pickup Clamp Shell. Use a 3-48 screw, #3 lockwasher, and 3-48 nut.

( ) Place the remaining 1/2" rubber grommet over the free ends of the cables prepared previously.

(√) Connect the red lead with the test clip to lug 4 of the miniature terminal strip (S-1). Solder on other side of terminal strip. Use the hole in the bottom of the lug.

(√) Connect the other red test lead (ignition pickup clip) to lug 3 of the miniature terminal strip (S-1). Use the hole in the bottom of the lug.

(√) Connect the black test lead to lug 2 of the miniature terminal strip (NS). Dress this lead under the terminal strip and insert it in the bottom hole (S-1). Use the hole in the bottom of the lug.

Refer to Pictorial 16 for the following steps.

(√) Bend the mounting foot and all lugs as shown in Pictorial 16.

(√) Connect the white wire of the 3-conductor cable to lug 4 of the miniature terminal strip (S-1).

(√) Connect the red wire to lug 3 of the miniature terminal strip (S-1).

(√) Connect the prepared pigtail to lug 2 of the miniature terminal strip (NS). Use sleeving.

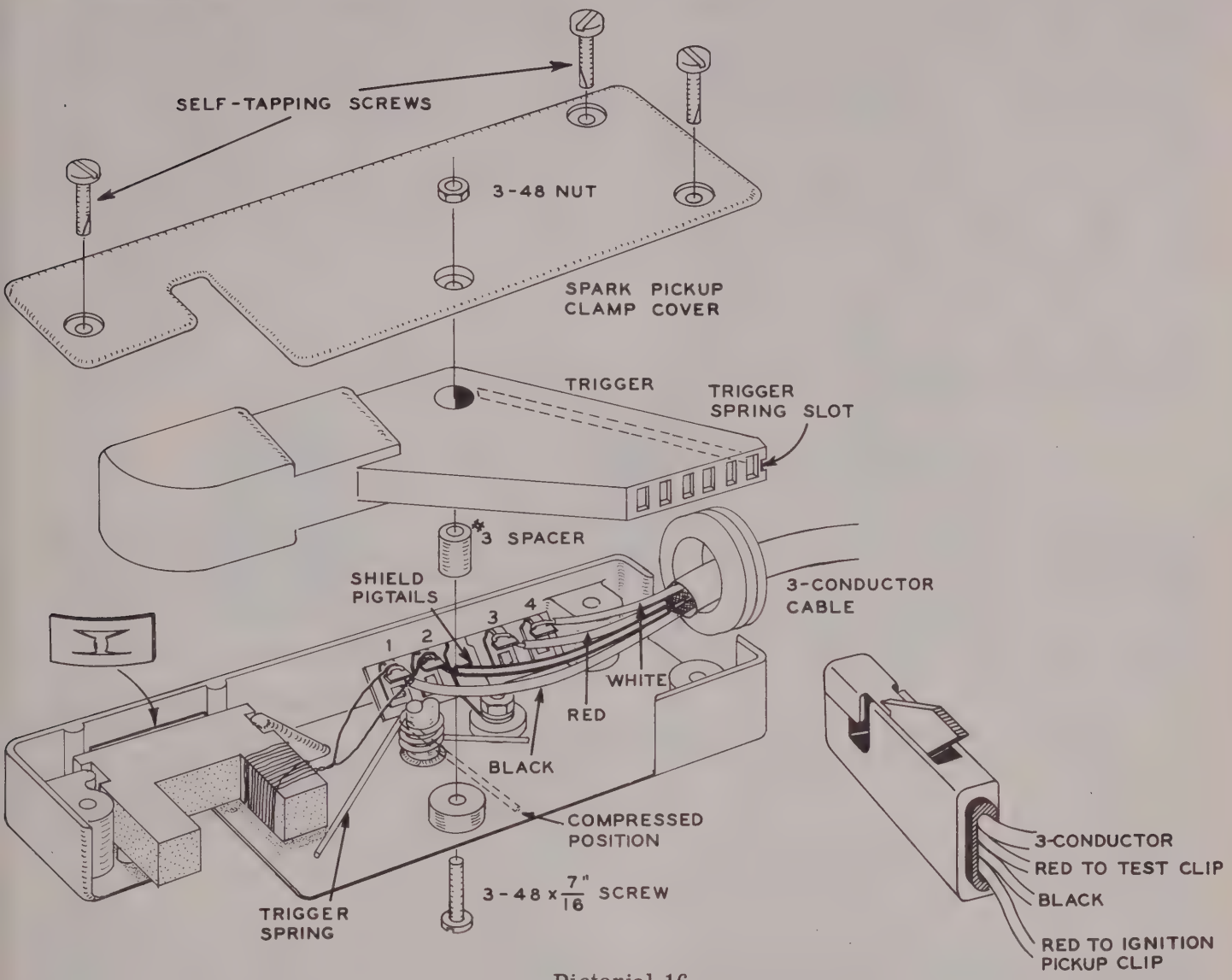
(√) Connect the black inner wire of the shielded cable to lug 1 of the miniature strip (NS).

(√) Place the pickup coil assembly into place. Insert the metal spring clip between the pickup coil and the clamp shell. Deform the clip, if necessary, to obtain snug fit.

(√) Connect either of the pickup coil wires to lug 1 of the terminal strip (S-2).

(√) Connect the remaining pickup coil wire to lug 2 of the terminal strip (S-2).

( ) Insert the 3-48 x 7/16" brass screw part way through the Spark Pickup Clamp Shell.




Pictorial 16

( ) Locate the spring and place it over the plastic stud located in the middle of the pickup shell.

( ) Place one end of the spring into the slot of the trigger portion of the pickup assembly.

( ) Compressing the spring as shown, place the trigger over the screw installed previously.

( ) Place the small #3 spacer over the screw and into the hole in the trigger.

( ) Place the rubber grommet in the cutout in the end of the Spark Pickup Clamp Shell, and arrange the cable and three wires as shown in Detail 16A.

( ) Place the cover of the Spark Pickup Clamp over the shell. Squeeze it together firmly so that the rubber grommet fits into the slot. Now, secure the cover with the small self-tapping screws. Hold the cover down while retightening screws.

( ) Place a 3-48 nut on the brass screw and tighten it snugly.

This completes the assembly of the HEATHKIT IO-20 Ignition Analyzer.

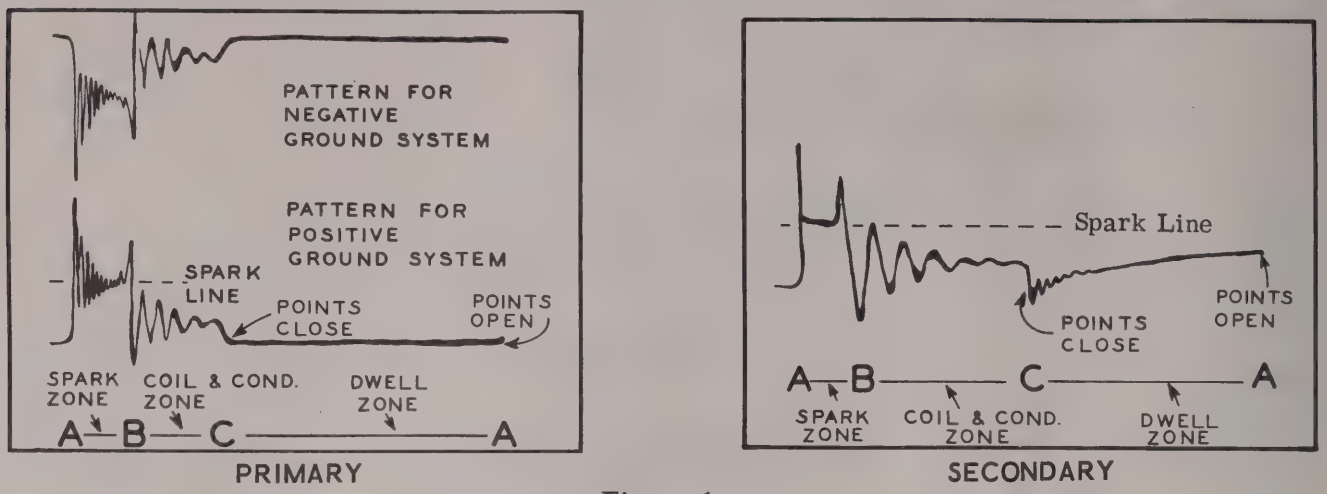



Figure 1

# INTRODUCTION TO IGNITION ANALYZERS

The ignition analyzer is a tool designed to aid in diagnosing ignition system difficulties. Through its use, abnormal conditions in the ignition system and combustion chamber can be readily located by comparing the patterns observed on the screen, to those of a standard trace from a normally operating system.

Since the ignition analyzer is a tool it must be well understood and used properly to fulfill its purpose.

The basic function of the ignition analyzer is to convert the complex electrical voltages developed during the ignition cycle into a visual display. Since a properly operating ignition system presents a characteristic pattern, any deviation from this pattern would indicate some type of difficulty. It is, therefore, necessary to know how each portion of the ignition system affects the normal pattern.

Figure 1 shows two normal patterns; a Primary and a Secondary. Although both traces are similar and both convey useful information, the Secondary trace is more sensitive and informative.

The left-hand traces of Figure 1 are typical Primary traces for one cycle of a normally operating ignition system. They start with the initiation of the spark when the points open, and end when the points open again for the next cycle. The primary trace represents the voltage across the breaker points.

NOTE: The Primary patterns will appear as shown in Figure 1, depending upon the battery polarity. Interpretation of the trace may be carried out with the pattern in either position, since the individual lines are significant rather than the entire picture. The traces in the rest of this manual are from a positive ground system.

When the points open, the spark jumps across the spark plug gap. As soon as the spark is initiated, coil-condenser oscillations take place in the coil primary and continue, diminishing in amplitude, until the spark ends. Oscillation appears again when the spark ends, due to the energy remaining in the coil.

These oscillations soon die out and end in a line which represents the DC voltage across the points. The Points Close Signal is shown by the rapid change as the voltage across the points drops to zero. The dwell zone or length of time the points remain closed is the length of the line up to the points open signal, indicating the start of another cycle.

We find from the preceding information that there is (A) a "Spark Zone;" (B) a "Coil-Condenser Zone," which shows the performance of these parts; (C) a "Points Close" signal, showing the operation of the points and the initiation of the dwell period; and (D) the "Dwell Zone," which shows the relative length of time the points are closed.

Referring to the secondary trace of Figure 1, notice that the first voltage peak developed when the points open. This high voltage causes the initial spark across the spark plug gap.

Once started, a lower voltage will sustain the spark, as indicated by the lower horizontal line. This line, called the "Spark Line," is very important since deviations in this portion of the trace will point out difficulties in the high tension circuits.
The "Coil-Condenser" zone is similar to the primary pattern, showing coil and condenser performance.

The "Points Close" zone is different from the primary trace due to the removal of the DC component by the transformer. When the points close there is a voltage induced in the secondary winding which oscillates for a short period of time. This is a very important portion of the trace since it shows proper closing of the points. The "Dwell Zone," as in the primary trace, shows the length of dwell time.

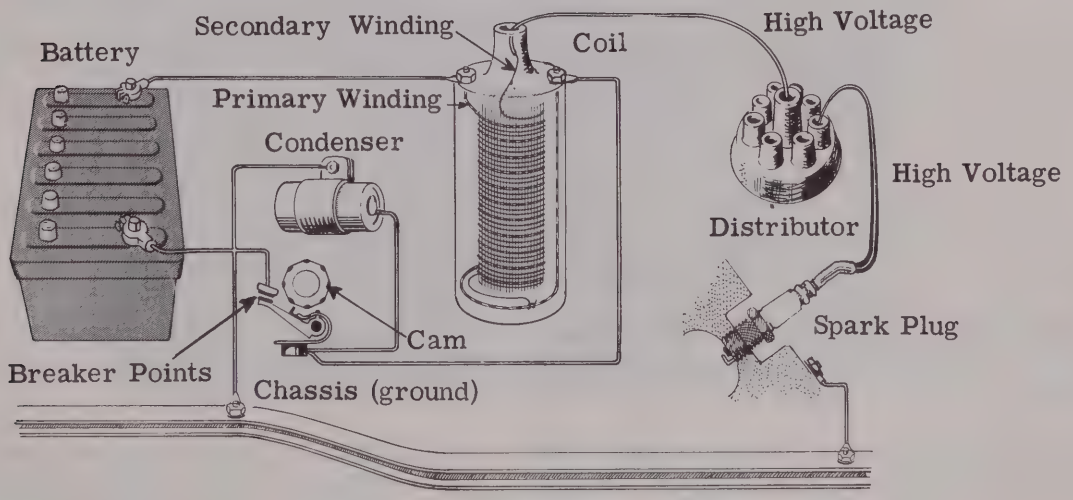



Figure 2

## DERIVATION OF AN IGNITION VOLTAGE

The traces representing the ignition voltage have been shown and discussed in the preceding sections. In order to better understand the information in the OPERATION section, we suggest that you carefully study Figure 2 and the following information.

Consider the breaker points as a switch. When the switch is closed, current from the battery flows through the coil. The current flow causes a magnetic field to be set up in the soft iron core of the coil. This magnetic field builds up relatively slowly (it is not an instantaneous occurrence). For this reason, the length of time the points remain closed (called "dwell") is important.

As soon as the switch opens, current ceases to flow from the battery through the coil. The collapse of the magnetic field is practically instantaneous. As this field collapses, a voltage is "generated" which tries to keep the current going. This voltage can approach several hundred volts in the coil primary. It is the job of the condenser to absorb this surge of voltage before it can arc across the points. At the same time this voltage surge occurs in the primary, a surge is induced into the secondary (which contains many more turns of wire). The net effect is to "step up" the primary voltage to a level sufficient to fire the spark plugs. This requires many thousands of volts, the actual voltage depending among other things on compression, air/fuel ratio, and spark plug gap.

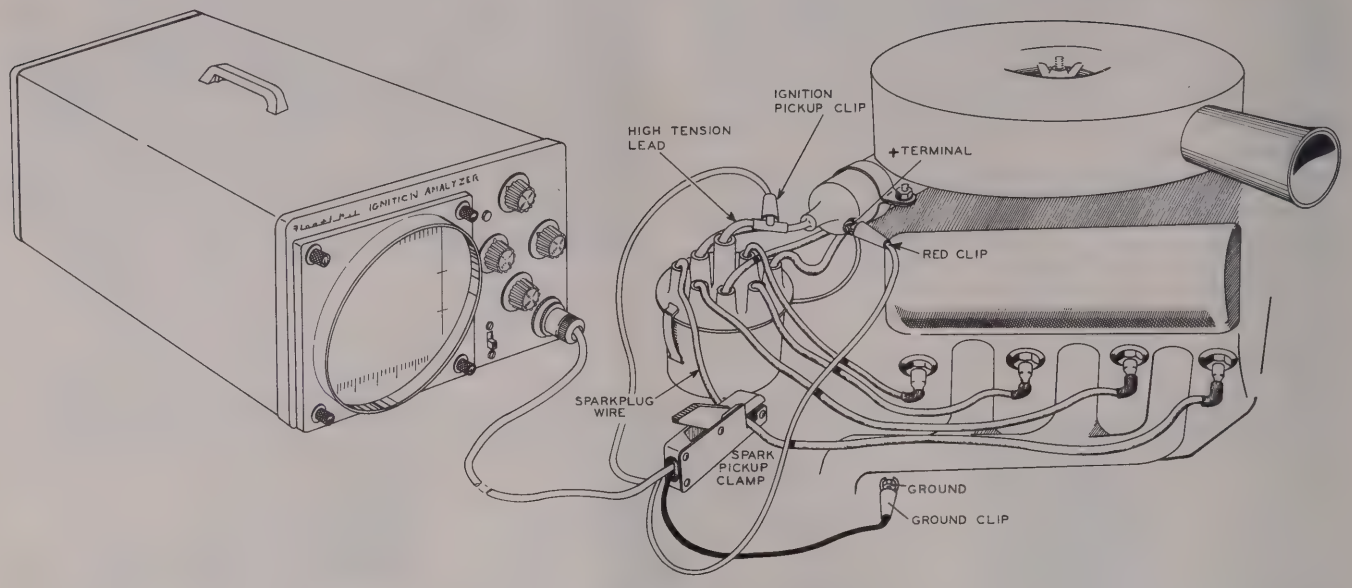



Figure 3

## HOOKUP PROCEDURE

( ) Connect the test cable to the Ignition Analyzer and secure it with the cable connector locking ring.

( ) Clip the Spark Pickup Clamp around the #1 spark plug wire. Be sure that the clamp is completely around the spark plug wire and does not touch any portion of the plug. Refer to Figure 3.

NOTE: This connection initiates the trace with #1 cylinder, with the others following in the firing order. If you desire to start the trace with another cylinder, it is only necessary to clip the Spark Pickup Clamp around the desired spark plug lead.

( ) Clip the black lead from the Spark Pickup Clamp to a good engine ground.

( ) Attach the Ignition Pickup Clip to the high-tension lead between the coil and the distributor.

( ) Clip the remaining red lead to the low voltage terminal on the distributor or at the coil end of the connecting wire if it is more easily reached.

The type of presentation which is to be used is simply switch selected on the front panel. The various combinations are:

PRIMARY PARADE
SECONDARY PARADE
PRIMARY SUPERIMPOSED
SECONDARY SUPERIMPOSED

The proper selection of the display to use will be covered in the following sections.

## OPERATION

### FINAL ADJUSTMENT

It will probably be necessary to make some adjustments when the IO-20 is used for the first time.

Connect the instrument to a 105-125 volt 50/60 cycle AC source. Set the controls as follows:

LEFT EDGE - maximum clockwise
RIGHT EDGE - maximum clockwise
VERT. CENTER - halfway

VERT. EXPAND - pushed in
SUPERIMPOSED/PARADE - PARADE
Function Switch - SECONDARY NORMAL

Figure 4

( ) Start the engine and set the throttle for a fast idle. Rotate the LEFT EDGE control counterclockwise until a trace is visible on the screen. Move the trace until the beginning is near the left edge of the screen.

( ) Adjust the VERT. CENTER control until the trace is in the center of the screen vertically.

( ) If the trace seems to flash on and off erratically, remove the access hatch cover and adjust the TRIGGER ADJUST control just beyond where a steady trace is presented.

( ) Adjust the FOCUS and ASTIGMATISM controls for the sharpest trace.

( ) Adjust the RIGHT EDGE control until the pattern for each cylinder is presented on the screen (six for a six cylinder engine, eight for an eight cylinder engine, etc.).

NOTE: Speeding up the engine will compress the trace toward the left. Advancing the RIGHT EDGE control will return the trace to full width.

( ) Advance the RIGHT EDGE control farther and notice that the trace expands to the right until the spark of a single cylinder can be made to fill the screen. For faster idling speeds it may be necessary to switch to the SECONDARY EXPAND position to obtain a single spark.

( ) By turning the LEFT EDGE control counterclockwise the whole display can be moved to the left on the screen. This allows the observation of individual cylinder traces, one after the other.

( ) To observe a portion of the spark signal in detail, pull out the VERTICAL EXPAND switch. This will increase the vertical height approximately 2 to 1.

( ) To view the same spark trace in more detail, switch the Function Selector to PRIMARY or SECONDARY EXPAND position. This will spread the trace horizontally.

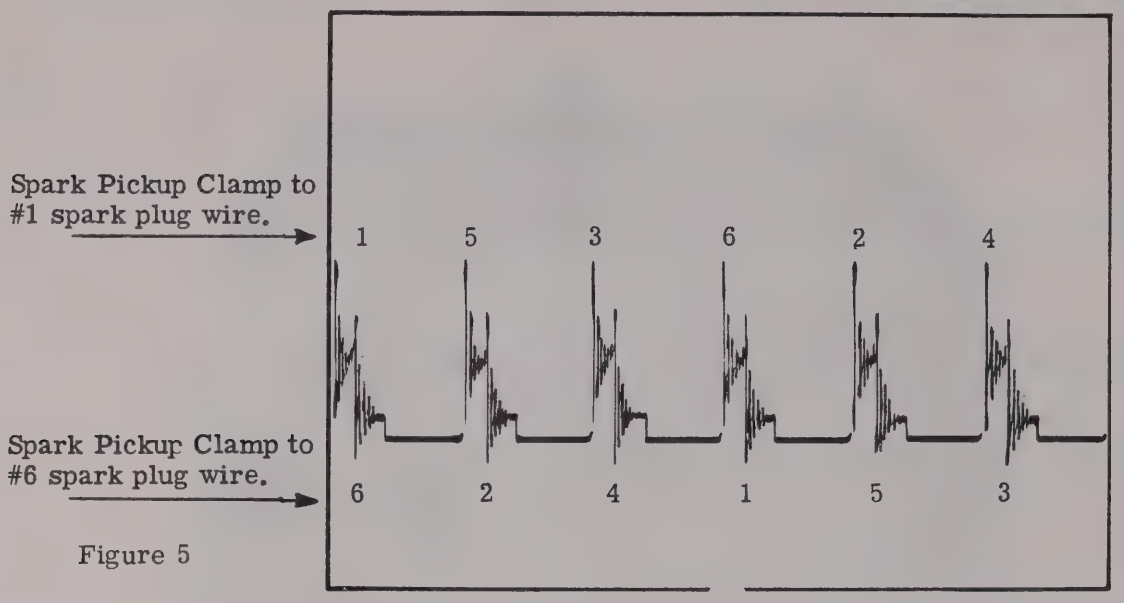



Figure 5

( ) Referring to Figure 5, notice that the first spark trace on the left end of the display is from the plug to which the Spark Pickup Clamp is attached.

The following spark traces appear in their normal firing order.

If maximum shift of the trace to the left does not enable you to view the last few spark traces, change the Spark Pickup Clamp to a spark plug wire in the middle of the firing order. For example, if the firing order is 1-5-3-6-2-4 and you cannot bring spark traces 2-4 in the screen with the LEFT EDGE control, shift the clamp to the #6 spark plug wire and observe 6-2-4-1-5-3 with 5-3 being off the screen. See Figure 5.

It is unlikely that this condition will exist with a 4 or 6 cylinder engine, but it may be present on an 8 or 12 cylinder engine at low engine speeds.

It is possible to view all cylinders at one time with the IO-20. This is a very important part of ignition analysis. Place the PARADE/SUPERIMPOSED switch to the SUPERIMPOSED position. Now, all the traces should be presented, one on top of the other. This enables you to spot a discrepancy in any one cylinder, since it will differ from the cylinders that are firing properly.

Dwell angle can be measured directly with the IO-20. The scale found on the screen has been calibrated for dwell angle, thereby eliminating the process of converting from dwell time to dwell angle.

It is desirable to measure the dwell angle with the unit set up for SUPERIMPOSED readings. Variations, such as cam wobble, are readily visible as a multiple Points Close Signal, as shown in Figure 6. If the wobble exceeds manufacturers limits, the distributor should be replaced or rebuilt.

## STANDARD IGNITION TEST PROCEDURE

It is very important that you have read and fully understand the information in the Introduction to Ignition Analyzers and Operation sections before proceeding.

The test procedure described in this section is not the only method that may be used. However, it has been tried and found satisfactory on many internal combustion engines. As you become more skilled in operating the IO-20 it is quite possible that you will find a method that will better fit your application.

This test procedure can be used under the following conditions:

1. Engine is not operating properly.
2. To verify work done on the ignition system.
3. Checking condition of components for preventive maintenance.

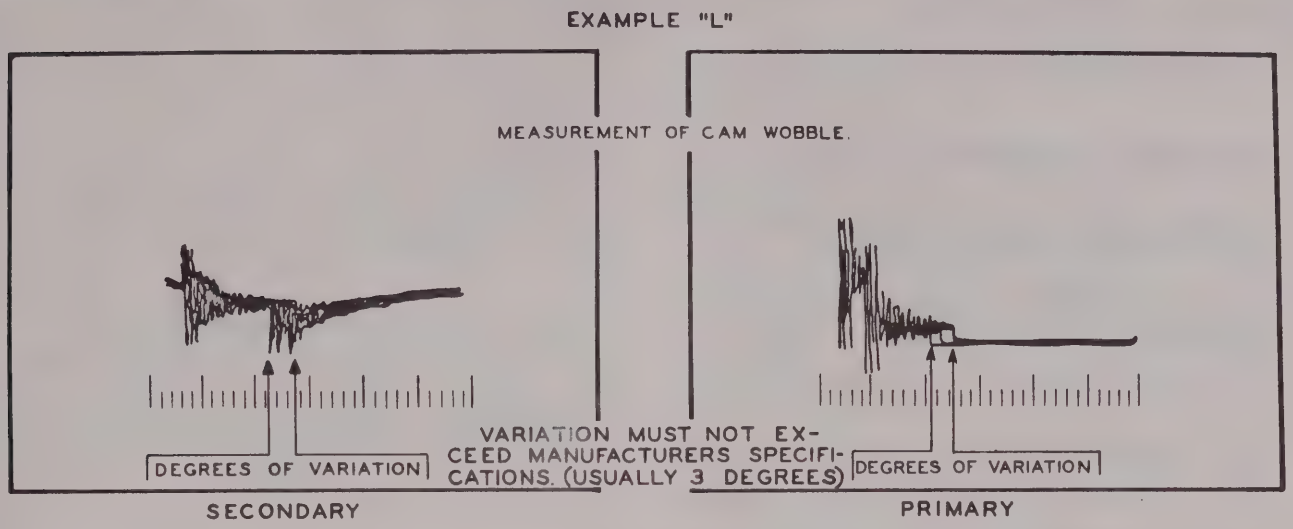



Figure 6

When analyzing an ignition system there are four questions which must be answered to arrive at a satisfactory diagnosis.

1. Are the traces normal in all respects?
2. If a defect is noticed, is it common to all cylinders?
3. In what manner do the waveshapes differ from a normal pattern?
4. In what zone is the difficulty occurring?

The following test procedure will answer these questions.

## PROCEDURE

A. Connect the IO-20 to the ignition system under test.

B. Start engine and adjust it to a fast idle.

C. Set the analyzer's controls to give a superimposed secondary normal display, with the pattern centered on the screen and spread between the lines marking the ends of the dwell angle scales.

D. Observe the pattern. If the ignition system is operating normally, there will be no large discrepancies over any portion of the trace.

If discrepancies are observed, they will be either of two types. Those that affect each trace of the superimposed patterns and those which affect less than all traces.

E. If every cylinder appears to be affected, the difficulty may be in any part of the ignition system that is common to all cylinders.

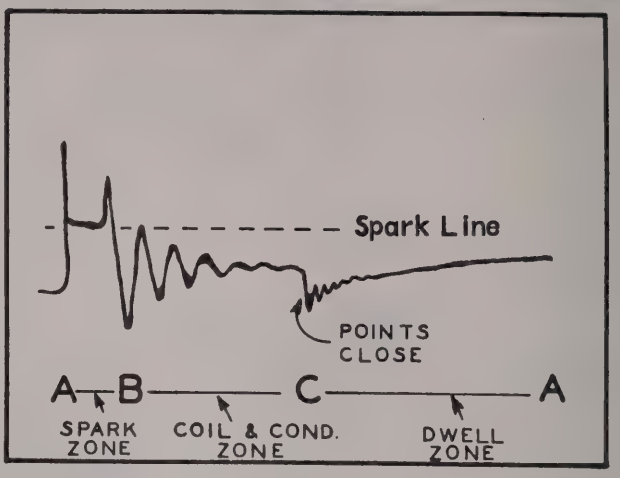
F. If the trouble is common to all cylinders, a more detailed view is desired. Switch to the PARADE pattern and spread the trace so that a single cylinder's trace covers the screen. The VERTICAL EXPAND switch may be pulled out for an even more detailed view.

G. After the difficulty has been diagnosed, repairs should be made. The repairs should be checked with the analyzer to be sure that no further difficulties are present.

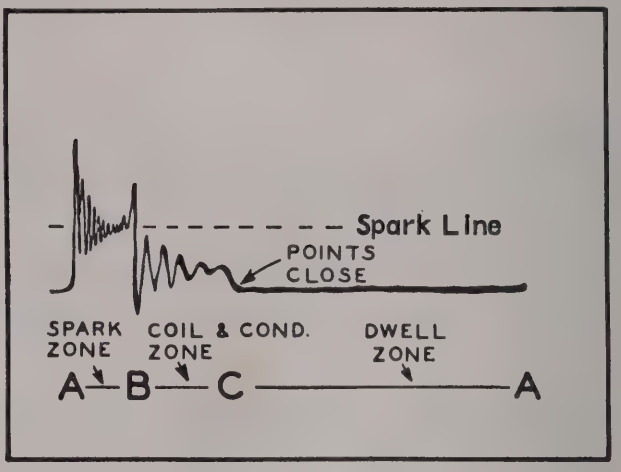
H. If the trouble is not common to all cylinders but is apparent in one or more, switch to the PARADE position and adjust the RIGHT and LEFT EDGE controls until all cylinders are presented. The first trace will be for #1 cylinder, and the remaining, in firing order. From this display it is possible to determine which cylinders are affected and which to view in detail. Detailed examination is accomplished as described previously, except that after spreading the pattern to show one cylinder only, all others may be viewed individually in firing order by turning the LEFT EDGE control. Determine the problem as before by comparing the abnormal trace with a normal trace.

## SUMMARY TEST PROCEDURE

1. Connect analyzer to ignition system under test.
2. Start engine and adjust to fast idle.
3. Adjust controls to give a SUPERIMPOSED SECONDARY NORMAL display.
4. Compare pattern obtained with that of a normally operating system.
5. If patterns are different, is the difference:
   A. Common to all cylinders.
   B. Common to less than all cylinders.
6. Locate "trouble zone" and probable cause of difficulty using PARADE SECONDARY EXPAND and VERTRICAL EXPAND as necessary.
7. Recheck work with analyzer.



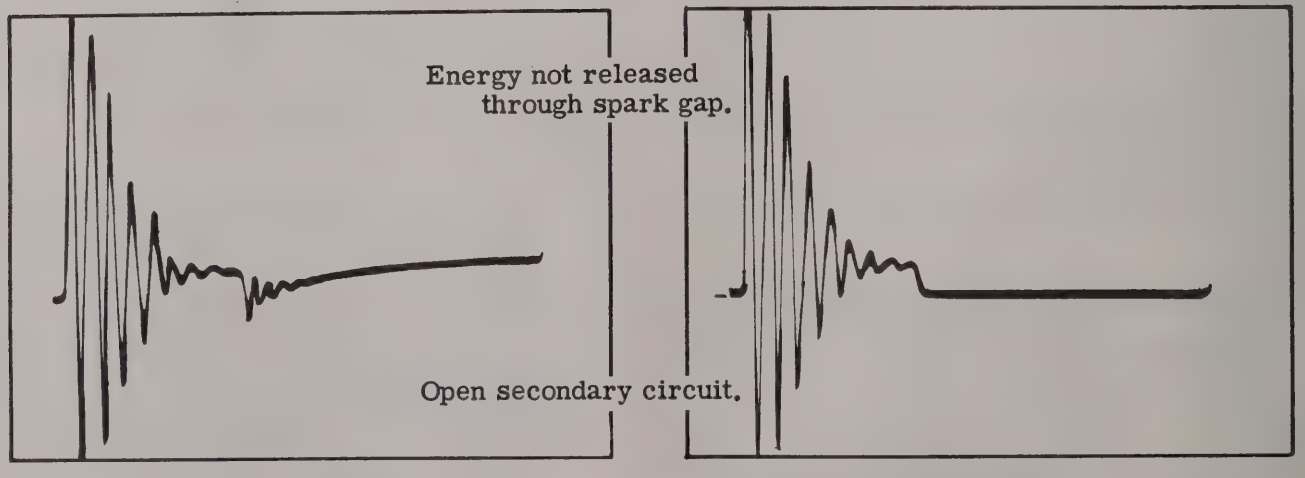

SECONDARY




PRIMARY

## INTERPRETATION OF THE TRACE

Example "A"



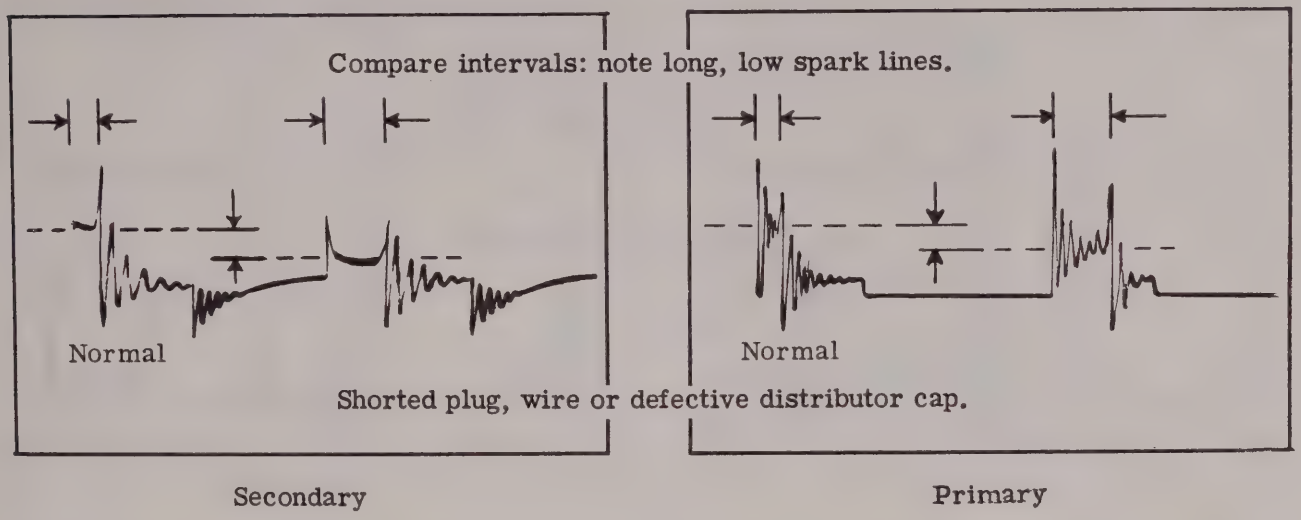

Secondary

Primary

Spark Zone

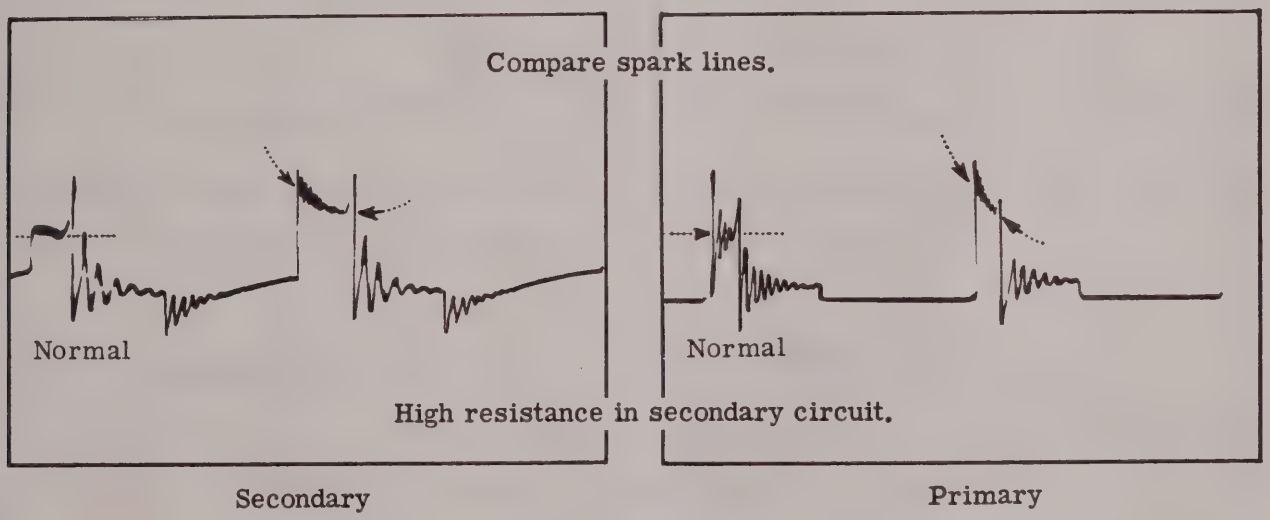
If section A-B is missing and the trace appears as in Example A, there is no spark. This may be caused by a loose plug wire, or a faulty coil producing insufficient voltage to jump a large gap in the plug.

Example "B"



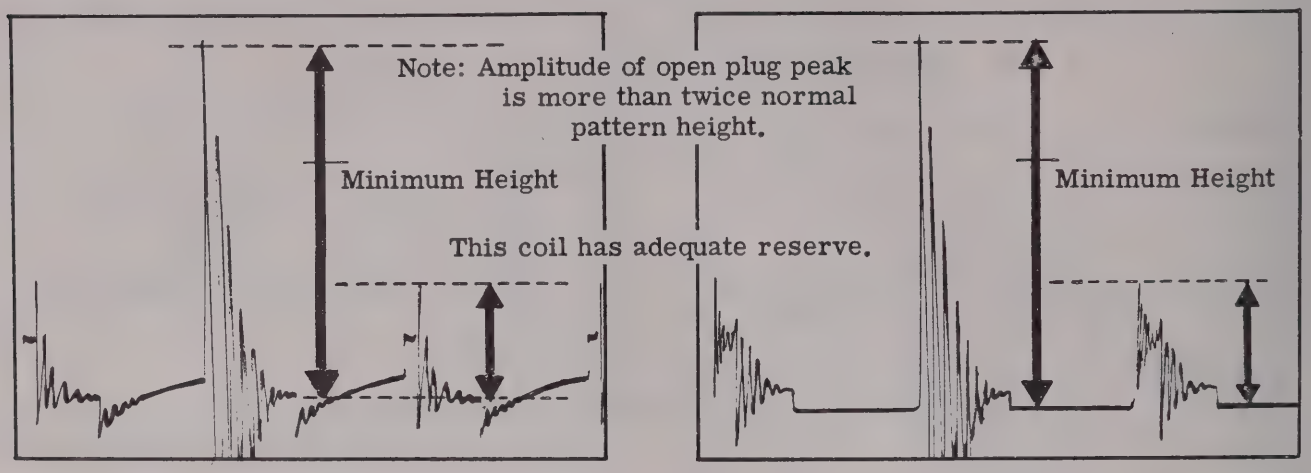

If the spark line is lower and of longer duration than normal the current has found an easier path. This would indicate too small a gap, a shorted plug, or plug lead making the gap in the distributor the only gap in the circuit.

Example "C"




A pronounced bending of the spark lines indicate a high resistance in the plug wire. Resistance wire is commonly used for spark plug leads to reduce ignition interference in automobile radios; therefore, some bending of the spark line may be normal.

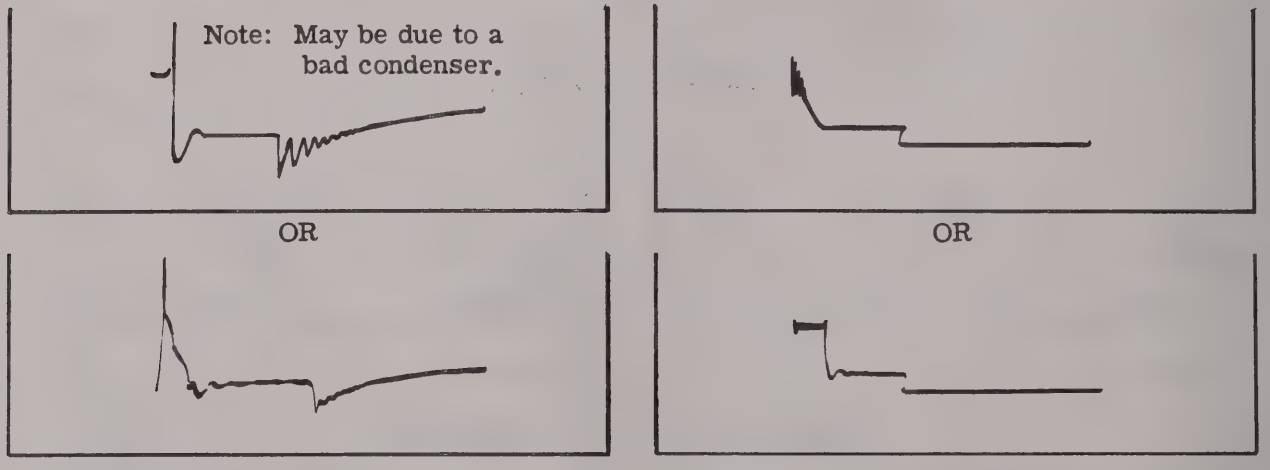
Example "D"


Note: Amplitude of open plug peak is more than twice normal pattern height.
Minimum Height
This coil has adequate reserve.
Minimum Height

Secondary Primary

The reserve voltage of a coil may be checked by using the spark trace. Disconnect one spark plug wire. The spark zone peak should be at least twice as high as that of a normal trace for adequate reserve voltage.

Example "E"

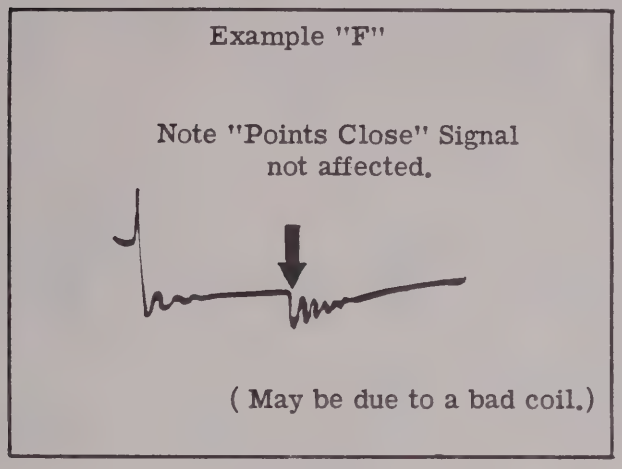



Secondary Primary

Coil-Condenser Zone

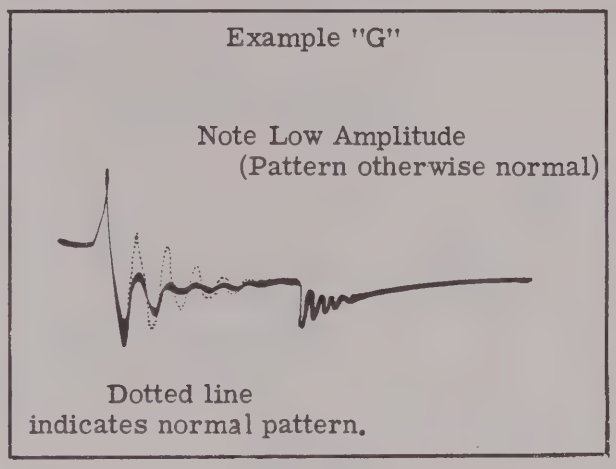
This zone may be affected by many components, namely, the coil, condenser, battery voltage, and open or shorted spark plugs. A bad coil will result in a trace like one of those shown in Example E.

Example "F"




Secondary

Example "G"



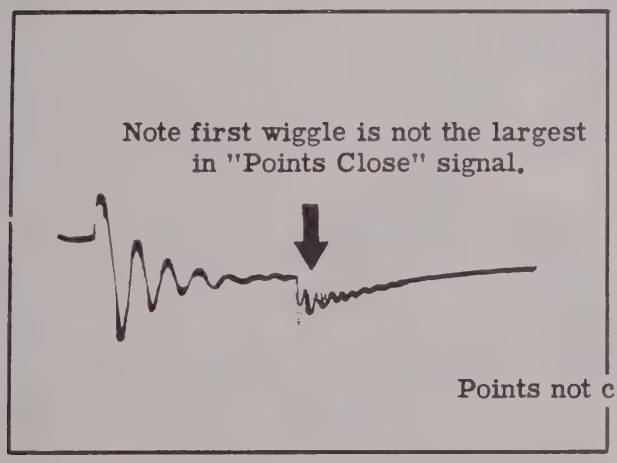

Secondary

A bad condenser will reduce the wiggles to almost a straight line without affecting the Points Close Signal. There must be at least 5 wiggles before the oscillation dies out.

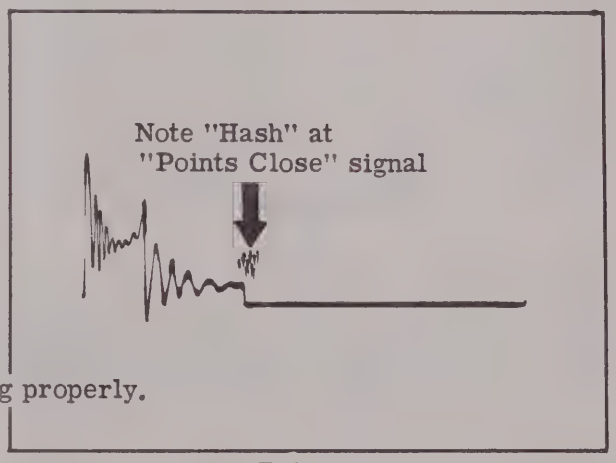
A low primary voltage will reduce the amplitude of the oscillations resulting in a display similar to that of a bad coil. Before replacing a coil for this defect, the primary voltage should be measured. A low voltage reading will indicate a discharged battery or a resistance in the primary wiring.

If the coil, condenser, points, rotor or primary wiring is causing trouble, it will be apparent on all cylinders. Trouble apparent only on one cylinder can be traced to spark plugs, spark plug wires, or distributor cap.

Example "H"




Secondary



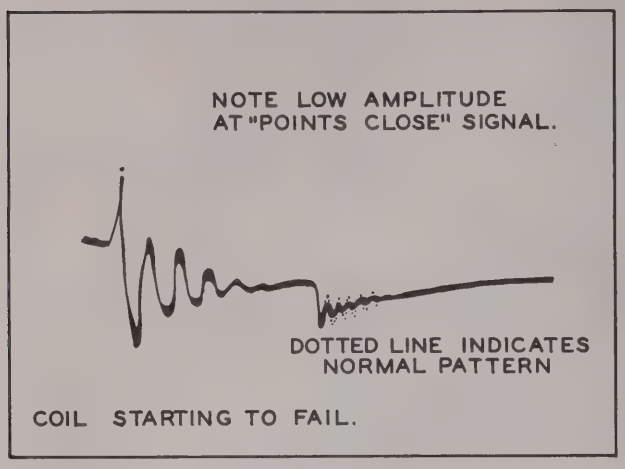

Primary

Points not closing properly.

Points Close Signal

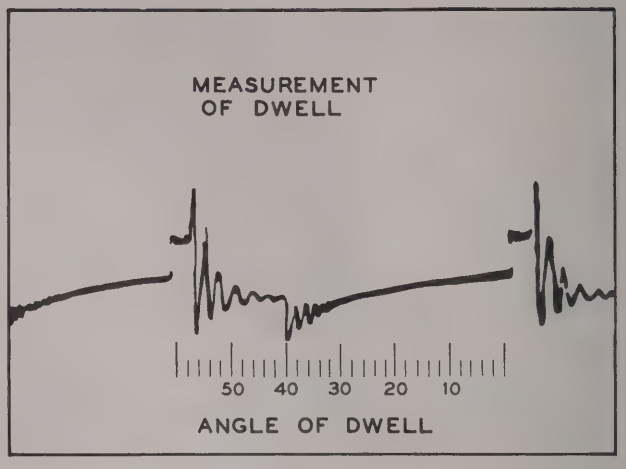
"Hash" around the Points Close Signal indicates improper closing of the points, or improper alignment of the points. Switching to the secondary pattern and expanding the trace a small oscillation will become apparent. The first wiggle should be of greater amplitude than all the others. If it is not, it is a sign that the points have built up a high resistance due to severe pitting, burning, or are not properly aligned.

EXAMPLE "J"




SECONDARY

EXAMPLE "K"



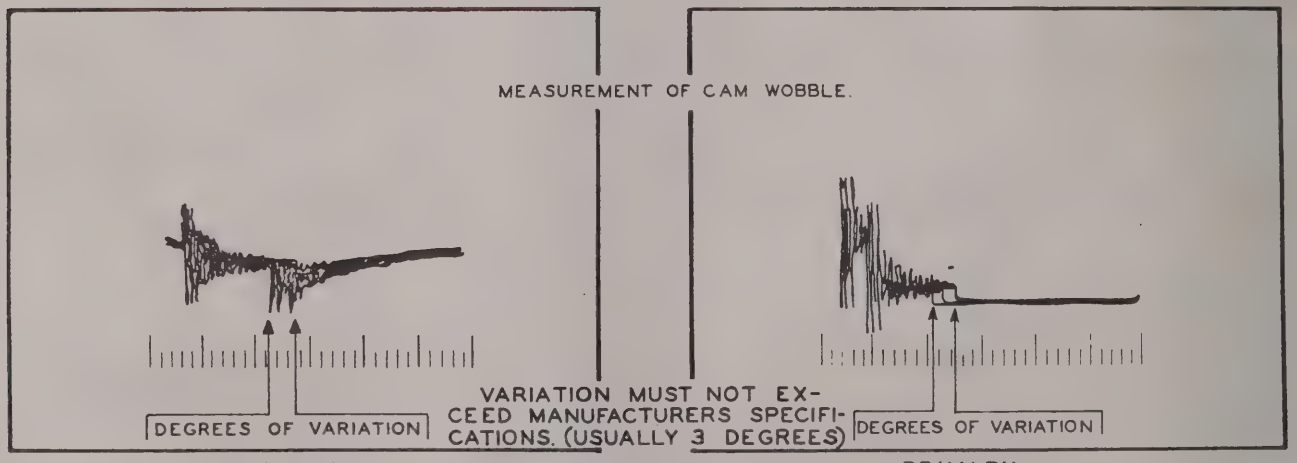

SECONDARY

Low amplitude of the Points Close Signal is an indication that the coil is starting to fail.

Dwell Angle Measurement

Set the analyzer to read a Primary or Secondary superimposed pattern. Using the LEFT and RIGHT EDGE controls, place the pattern between the beginning and end of the dwell markings. Read the marking found at the beginning of the Points Close Signal. This is calibrated directly in degrees. Dwell measurements should be made with the engine running at a low idling speed.

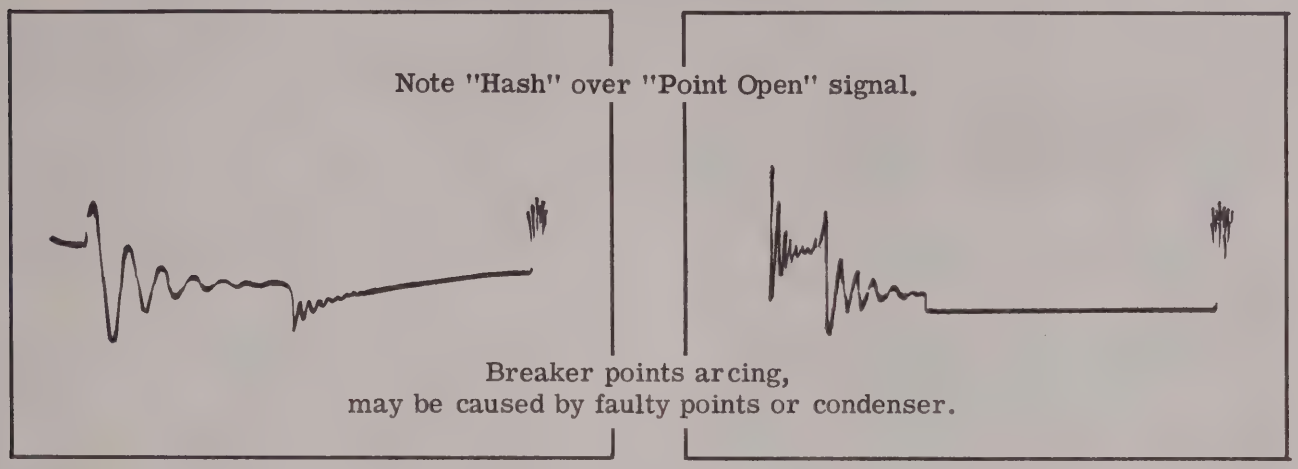
EXAMPLE "L"


MEASUREMENT OF CAM WOBBLE.
DEGREES OF VARIATION
VARIATION MUST NOT EXCEED MANUFACTURERS SPECIFICATIONS. (USUALLY 3 DEGREES)
DEGREES OF VARIATION

SECONDARY PRIMARY

Dwell may also be measured using a single spark trace expanded between the dwell scale ends. It is possible to measure "cam wobble" by using the dwell angle pattern. Cam wobble is indicated by a multiple points close signal. If the wobble exceeds manufacturers specifications (usually 3 degrees), the distributor should be rebuilt or replaced. NOTE: Cam wobble may also be due to uneven cam wear, worn bearings, or a bent distributor shaft.

EXAMPLE "M"




SECONDARY

PRIMARY

Points Open Signal

Flashing or arcing of the points as they open is shown by "hash" over the points open signal. This can be caused by defective points or a defective condenser.

## MOBILE APPLICATION OF THE IO-20

Mobile application of the IO-20 requires the use of a 117 V AC power supply. For automobiles, boats, and planes equipped with storage battery, suitable inverters are available.

The vibrator or transistor type of invertor is usually the lowest in cost and is very well suited for this application. Such inverters are produced by Heath Company, Terado, Travelectric, and Radiart. Be sure that the unit purchased has a rating of at least 30 watts and is 60 or 115 cycle.

CAUTION: Under no circumstances should you attempt to monitor the screen of an Ignition Analyzer while operating a motor vehicle. Either take a driver or someone to observe the trace while you drive.

## MAGNETO IGNITION SYSTEMS

Most two cycle and small four cycle internal combustion engines use the magneto type ignition system to eliminate the necessity of using a battery. This type of engine is commonly used on lawn mowers, boats, and chain saws.

The operating principle of a magneto ignition system is primarily the same as the battery supply ignition system. The magneto system uses a coil, condenser, and breaker points. The breaker points are not always accessible; therefore, it is often impractical to obtain primary traces. As stressed earlier, the secondary trace is usually used instead of the primary in engine testing since it is more informative.

If the magneto system utilizes a distributor for multicylinder engines, the connections should be made the same as for a standard coil-distributor system.

In the more common magneto type engine, separate breaker points are used for each cylinder. Therefore, each cylinder spark cycle must be individually viewed for multicylinder engines. Connections to this type system are made by connecting both the Spark Pickup Clamp and the Ignition Clip to the spark plug wire of the cylinder you wish to check. The ground clip is fastened to the engine block, and the Primary clip is not used.

The waveshapes observed will usually correspond to those found in a battery supplied system. Troubles common to both types of systems will give similar deviations and variations of the trace.

If it is necessary to observe a parade pattern in a multicyclinder engine not having a distributor, each spark plug wire can be jumpered together with clips similar to the Ignition Pickup Clip.

This effectively connects the Ignition Pickup Clip to all cylinders so that each spark plug firing will be shown for every ignition cycle.

# IN CASE OF DIFFICULTY

1. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the constructor.

2. It is interesting to note that about 90% of the kits that are returned for repair, malfunction due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as illustrated in the Figures found in the SOLDERING TECHNIQUES section of this manual.

3. Check to be sure that all tubes are in their proper locations. Make sure that all tubes light up properly.

4. Check the tubes with a tube tester or by substitution with tubes of the sames types and known to be good.

5. Check the values of the component parts. Be sure that the proper part has been wired into the circuit, as shown in the pictorial diagrams and as called out in the wiring instructions.

6. Check for bits of solder, wire ends or other foreign matter which may be lodged in the wiring beneath the chassis.

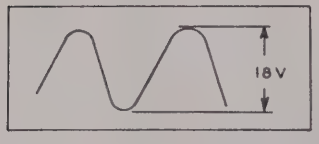
7. If erratic triggering occurs, we suggest that the Spark Plug Clamp be checked for possible accumulation of grease on the trigger or other pickup surfaces.

8. If, after careful checks, the trouble is still not located and a voltmeter is available, check voltage readings against those found on the Schematic Diagram. NOTE: All voltage readings were taken with a HEATHKIT Vacuum Tube Voltmeter. Voltages may vary 10% due to line voltage variations.

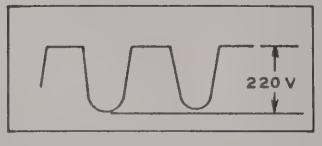
9. A review of the Circuit Description and Block Diagrams will prove helpful in indicating where to look for trouble.

10. If an oscilloscope is available you may wish to check waveforms at various points in the circuit. The important test points and their waveshapes are shown below. The jumper wires shown in Figure 7 should be installed before any measurements are made.

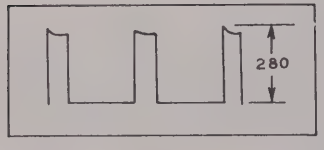
V1 PIN 3



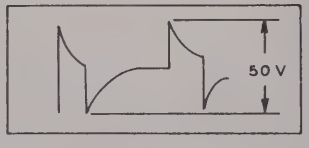

V1 PIN 8




V2 PIN 1

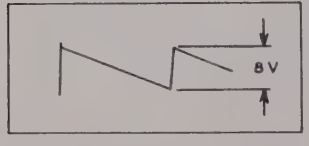



V3 PIN 8



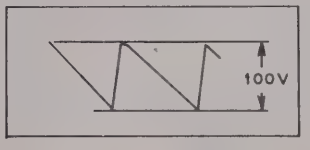

Amplitude varies with setting of LEFT EDGE control 0-180 volts.

V3 PIN 2



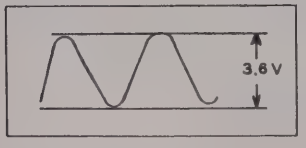

Amplitude varies with setting of LEFT EDGE control 0-25 volts.

V4 PIN 1 TO PIN 6 (ground lead to pin 6).

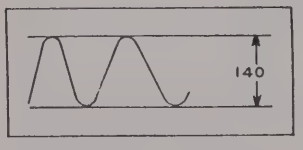



Amplitude varies with setting of RIGHT EDGE control 20-150 volts.

V5 PIN 2




V5 PIN 1




The voltages shown on the above diagrams are only approximate and should serve only as a guide in helping to locate errors.

| SYMPTOM | POSSIBLE CAUSE |
|---|---|
| Pilot lamp not lit. | Defective IV2, blown fuse, wiring error. |
| No horizontal trace with jumpers in place. | Defective 6EA8, or sweep charging diode D4. Wiring error, improper vertical centering, check tube operating voltages. |
| Trace cannot be centered horizontally. | Defective 12AU7 at V3, 12AX7 at V4, diode D4 or LEFT EDGE control. Check tube operating voltages. |
| No horizontal expansion. | Improperly wired selector switch, sweep forming capacitor C12 open or not connected. |
| No vertical deflection. | Defective 12AX7 at V5, wiring error on selector switch, center conductor of gray cable in cable harness short circuited to ground. C14, C15, or C17 defective. |
| Trace cannot be centered vertically. | R28, R31, R33, or R35 wrong value. Defective 12AX7 at V5. |
| Excessive vertical height. | VERTICAL EXPAND switch shorted, R24 or R25 wrong value. C14 or C15 defective. |
| Trace too dim or bright. | Defective component in high voltage supply. R41 wrong value. |
| Trace is blurred. | FOCUS and ASTIGMATISM controls improperly adjusted, excessive brightness, defective CR tube. |

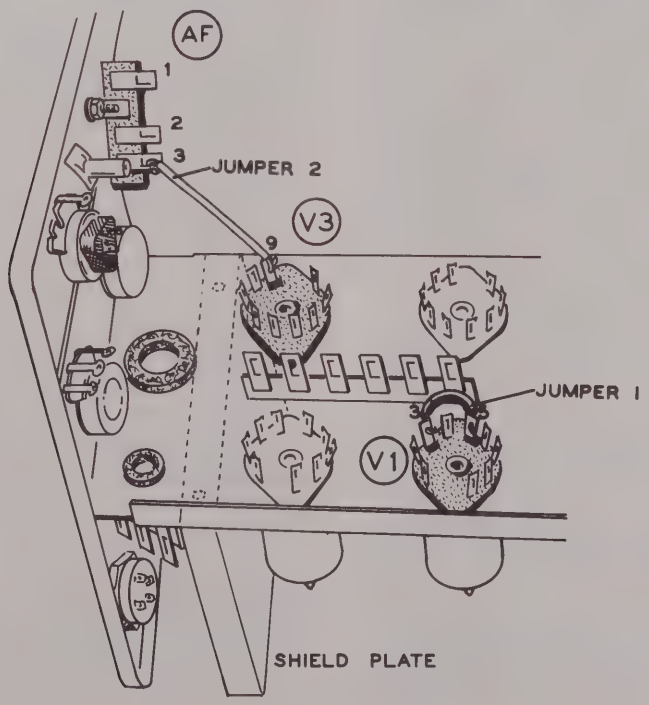



Figure 7

# SERVICE INFORMATION

## SERVICE

If, after applying the information contained in this manual and your best efforts, you are still unable to obtain proper performance, it is suggested that you take advantage of the technical facilities which the Heath Company makes available to its customers.

The Technical Consultation Department is maintained for your benefit. This service is available to you at no charge. Its primary purpose is to provide assistance for those who encounter difficulty in the construction, operation or maintenance of HEATHKIT equipment. It is not intended, and is not equipped to function as a general source of technical information involving kit modifications nor anything other than the normal and specified performance of HEATHKIT equipment.

Although the Technical Consultants are familiar with all details of this kit, the effectiveness of their advice will depend entirely upon the amount and the accuracy of the information furnished by you. In a sense, YOU MUST QUALIFY for GOOD technical advice by helping the consultants to help you. Please use this outline:

1. Before writing, fully investigate each of the hints and suggestions listed in this manual under "IN CASE OF DIFFICULTY." Possibly it will not be necessary to write.

2. When writing, clearly describe the nature of the trouble and mention all associated equipment. Specifically report operating procedures, switch positions, connections to other units and anything else that might help to isolate the cause of trouble.

3. Report fully on the results obtained when testing the unit initially and when following the suggestions under "IN CASE OF DIFFICULTY." Be as specific as possible and include voltage readings if test equipment is available.

4. Identify the kit model number and date of purchase, if available.

5. Print or type your name and address, preferably in two places on the letter.

With the preceding information, the consultant will know exactly what kit you have, what you would like it to do for you and the difficulty you wish to correct. The date of purchase tells him whether or not engineering changes have been made since it was shipped to you. He will know what you have done in an effort to locate the cause of trouble and, thereby, avoid repetitious suggestions. In short, he will devote full time to the problem at hand, and through his familiarity with the kit, plus your accurate report, he will be able to give you a complete and helpful answer. If replacement parts are required, they will be shipped to you, subject to the terms of the Warranty.

The Factory Service facilities are also available to you, in case you are not familiar enough with electronics to provide our consultants with sufficient information on which to base a diagnosis of your difficulty, or in the event that you prefer to have the difficulty corrected in this manner. You may return the completed instrument to the Heath Company for inspection and necessary repairs and adjustments. You will be charged a minimal service fee, plus the price of any additional parts or material required. However, if the completed kit is returned within the Warranty period, parts charges will be governed by the terms of the Warranty. State the date of purchase, if possible.

Local Service by Authorized HEATHKIT Service Centers is also available in some areas and often will be your fastest, most efficient method of obtaining service for your HEATHKIT equipment. Although you may find charges for local service somewhat higher than for factory service, the amount of increase is usually offset by the transportation charge you would pay if you elected to return your kit to the Heath Company.

HEATHKIT Service Centers will honor the regular 90 day HEATHKIT Parts Warranty on all kits, whether purchased through a dealer or directly from Heath Company; however, it

will be necessary that you verify the purchase date of your kit.

Under the conditions specified in the Warranty, replacement parts are supplied without charge; however, if the Service Center assists you in locating a defective part (or parts) in your kit, or installs a replacement part for you, you may be charged for this service.

HEATHKIT equipment purchased locally and returned to Heath Company for service must be accompanied by your copy of the dated sales receipt from your authorized HEATHKIT dealer in order to be eligible for parts replacement under the terms of the Warranty.

THIS SERVICE POLICY APPLIES ONLY TO COMPLETED EQUIPMENT CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Equipment that has been modified in design will not be accepted for repair. If there is evidence of acid core solder or paste fluxes, the equipment will be returned NOT repaired.

For information regarding modification of HEATHKIT equipment for special applications, it is suggested that you refer to any one or more of the many publications that are available on all phases of electronics. They can be obtained at or through your local library, as well as at most electronic equipment stores. Although the Heath Company sincerely welcomes all comments and suggestions, it would be impossible to design, test, evaluate and assume responsibility for proposed circuit changes for special purposes. Therefore, such modifications must be made at the discretion of the kit builder, using information available from sources other than the Heath Company.

## REPLACEMENTS

Material supplied with HEATHKIT products has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information.

A. Thoroughly identify the part in question by using the part number and description found in the manual Parts List.

B. Identify the type and model number of kit in which it is used.

C. Mention date of purchase.

D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. PLEASE DO NOT RETURN THE ORIGINAL COMPONENT UNTIL SPECIFICALLY REQUESTED TO DO SO. Do not dismantle the component in question as this will void the guarantee. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

## SHIPPING INSTRUCTIONS

In the event that your instrument must be returned for service, these instructions should be carefully followed.

ATTACH A TAG TO THE EQUIPMENT BEARING YOUR NAME, COMPLETE ADDRESS, DATE OF PURCHASE, AND A BRIEF DESCRIPTION OF THE DIFFICULTY ENCOUNTERED. Wrap the equipment in heavy paper, exercising care to prevent damage. Place the wrapped equipment in a stout carton of such size that at least three inches of shredded paper, excelsior, or other resilient packing material can be placed between all sides of the wrapped equipment and the carton. Close and seal the carton with gummed paper tape, or alternately, tie securely with stout cord. Clearly print the address on the carton as follows:

To: HEATH COMPANY
Benton Harbor, Michigan

Include your name and return address on the outside of the carton. Preferably affix one or more "Fragile" or "Handle With Care" labels to the carton, or otherwise so mark with a crayon of bright color. Ship by parcel post or prepaid express; note that a carrier cannot be held responsible for damage in transit if, in HIS OPINION, the article is inadequately packed for shipment.

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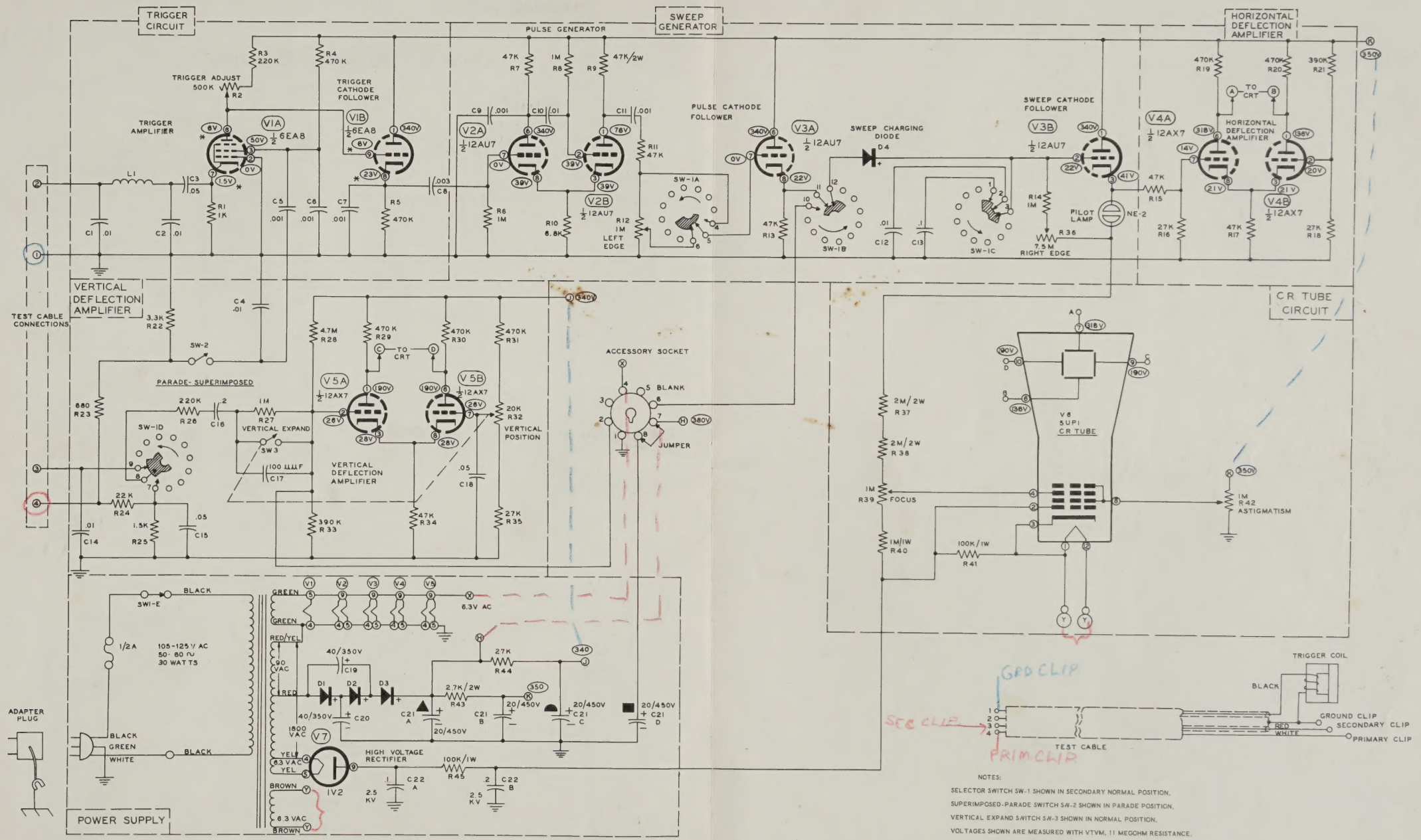



HEATHKIT / DAYSTROM

IGNITION ANALYZER MODEL IO-20

NOTES:

SELECTOR SWITCH SW-1 SHOWN IN SECONDARY NORMAL POSITION.

SUPERIMPOSED-PARADE SWITCH SW-2 SHOWN IN PARADE POSITION.

VERTICAL EXPAND SWITCH SW-3 SHOWN IN NORMAL POSITION.

VOLTAGES SHOWN ARE MEASURED WITH VTVM, 11 MEGOHM RESISTANCE.

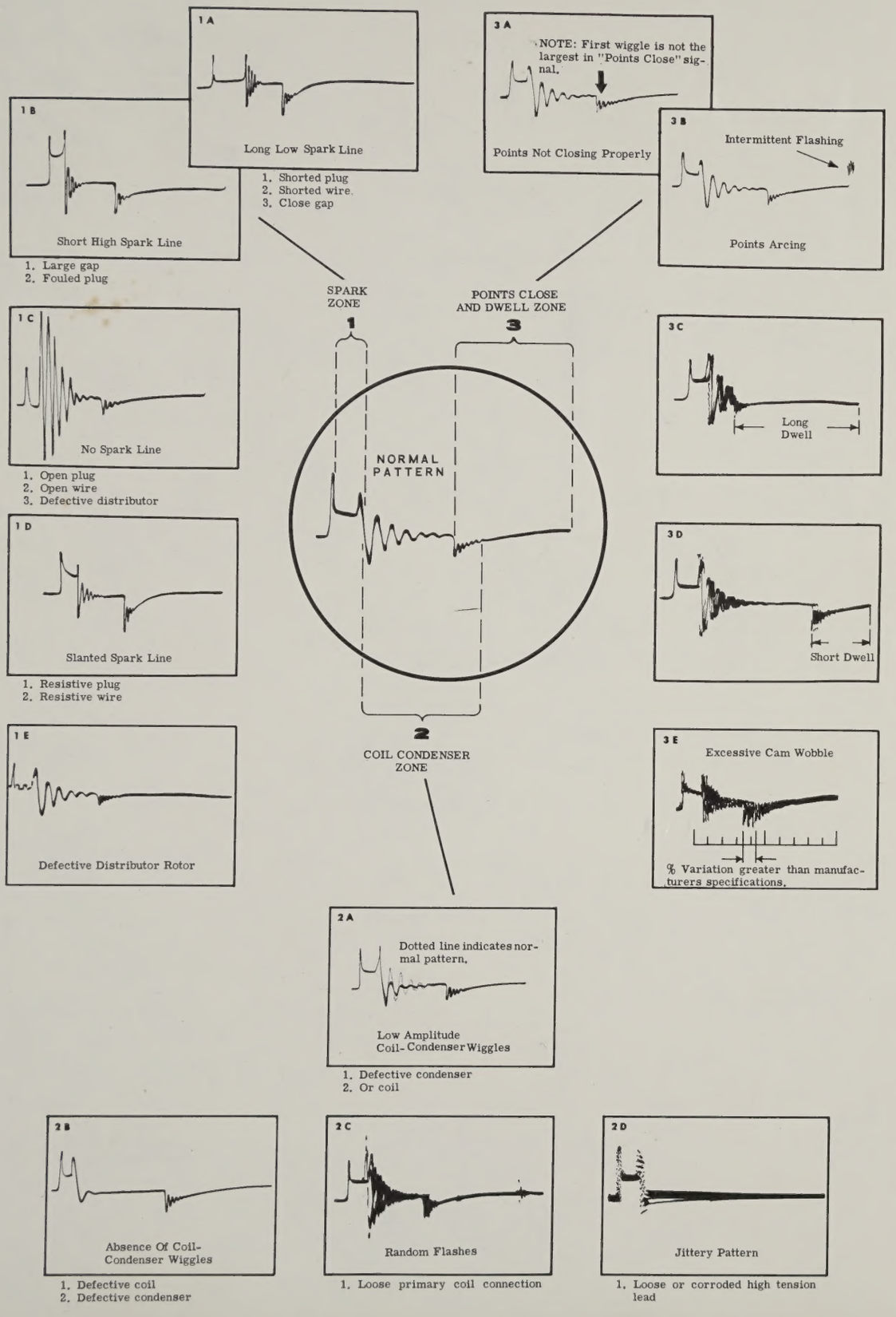
ALL RESISTORS ARE MARKED IN OHMS AND ARE 1/2 WATT UNLESS OTHERWISE SPECIFIED.

ALL CAPACITORS ARE MARKED IN μfd UNLESS OTHERWISE SPECIFIED.

MULTIPLIERS; K 1000 M 1,000,000

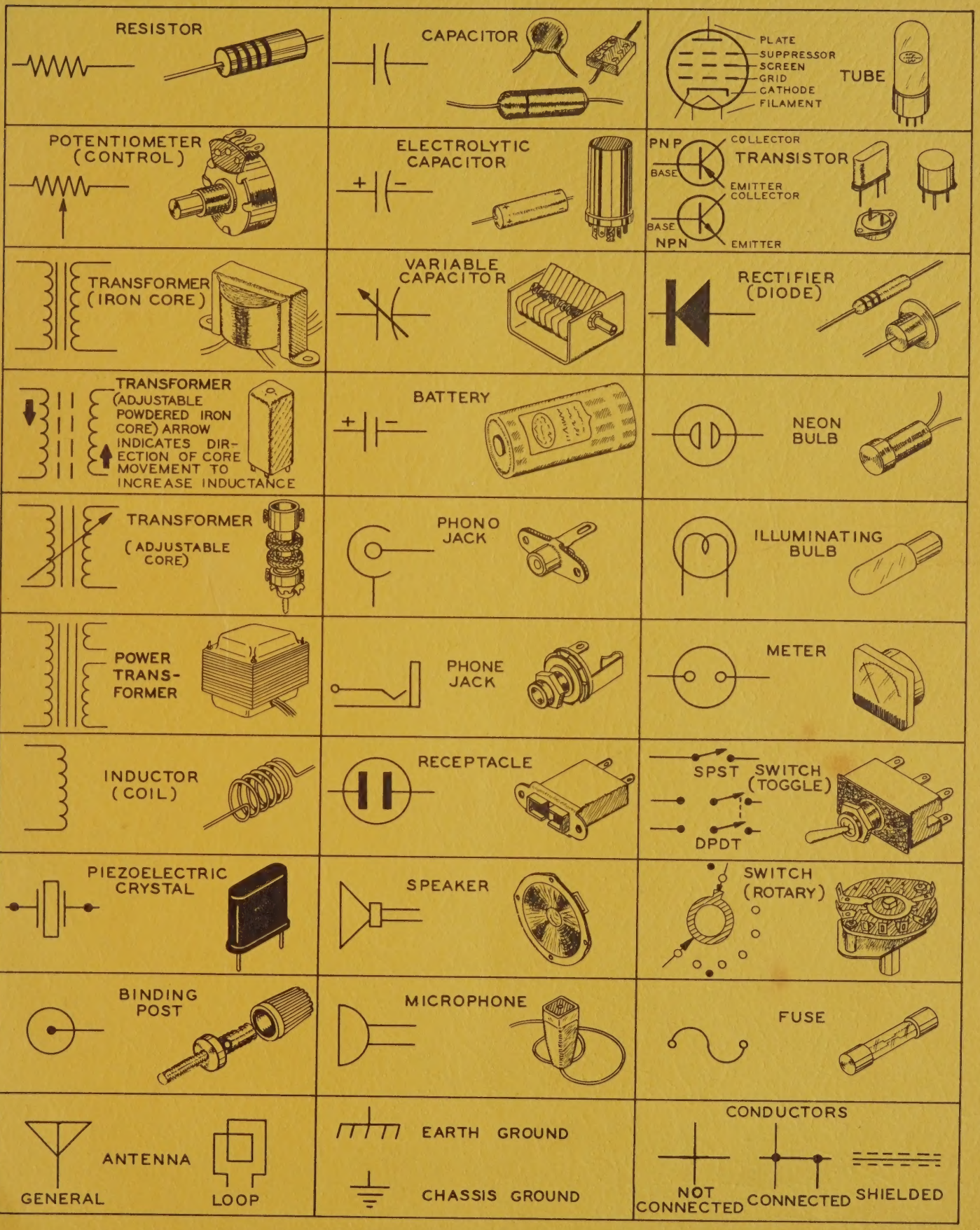
* VOLTAGE VARIES WITH CONTROL SETTINGS.

# DIAGNOSIS CHART



# TYPICAL COMPONENT TYPES

This chart is a guide to commonly used types of electronic components. The symbols and related illustrations should prove helpful in identifying most parts and reading the schematic diagrams.



# HEATH COMPANY

BENTON HARBOR, MICHIGAN

*a subsidiary of*

**DAYSTROM, INCORPORATED**

***THE WORLD'S FINEST ELECTRONIC EQUIPMENT IN KIT FORM***

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